CHEMICAL ENGINEERING PROGRESS

CEP

AUGUST 1957

STAINLESS TEST PROGRAM

High-manganese stainless steels are coming of age, may find many applications in the chemical processing field by offering strategic substitution qualities should nickel again go into short supply. A broad testing program is underway, but help is needed from more chemical companies.

POLLUTION AND THE CHEMICAL ENGINEER

Controlling pollution before it leaves the source is a task for which chemical engineers are eminently suited. CEP BONUS ARTICLE: What solvent-emission sleuths in Los Angeles found out about distribution of many products of chemical and petroleum industries.

NEW UNITED ENGINEERING CENTER

Symbolic and practical, the location of the new United Engineering Center will be on beautiful United Nations Plaza in New York. Preliminary plans for the building, which will house the five major engineering societies, are in the works.

STRATEGIC PACIFIC NORTHWEST

Long regarded as being "too far" from the market, the booming Pacific Northwest is actually closest to the future consumers of East Asia. Further, it contains rich resources which might at some future date have to be defended.

PLUS:

Teamwork in production planning · Statistical Analysis in polymerization and in quality control · Materials at low temperatures III · Pneumatic thermometer and hygrometer · Are you in the "small business" category? · Baltimore meeting final · A.I.Ch.E. officer-candidates.

Chemical Engineering Progress

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August, 1957 • Volume 53, No. 8

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departmental features

CEP

Published monthly by American Institute of Chemical Engineers at 15 North Seventh Street, Philadelphia 6, Pennsylvania. Editorial and Advertising Offices, 25 West 45th Street, New York 36, N. Y. Communications should be sent to the Editor. Statements and opinions in *Chemical Engineering Progress* are those of the contributors, and the American Institute of Chemical Engineers assumes no responsibility for them. Subscriptions: U. S. and possessions, one year \$6.00; two years \$10.00 (Applies to U. S. and possessions only). Canada, \$6.50; Pan American Union, \$7.50; Other Foreign, \$8.00. Single copies of *Chemical Engineering Progress* older than one year cost \$1.00 a copy; others are 75 cents. Entered as second class matter December 9, 1946, at the Post Office at Philadelphia, Pennsylvania, under Act of August 24, 1912.

Member of Audit Bureau of Circulations. *Chemical Engineering Progress* is indexed regularly by Engineering Index, Inc.

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Cover by *Milton Wynne Associates*

what's in this issue

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Noted and quoted

THE PACIFIC NORTHWEST: HOPE OF OUR INDUSTRIAL FUTURE

James T. Sheehy * | Rayonier, Incorporated, New York, N. Y.

The time has come when we should realize that our Pacific Northwest is rich in resources that the rest of the world would fight for, and that it constitutes the producing and manufacturing region nearest the expanding markets of East Asia.

What are these resources? They may be listed as follows:

- *Water Supply:* One of the serious problems facing the United States today is that of water supply. The need of water prevails throughout the nation but is most serious in the areas of major population. It is no problem, however, in the Northwest where you find the most prolific supply of surface water anywhere in the civilized world.
- *Hydro-Power:* The hydro-power potential is unequaled anywhere except as the Russians have successfully veiled from our eyes their natural advantages. British Columbia forecasts an electric power consumption of 10 to 20,000,000 hp. by 1970. Washington, Oregon, and Idaho expect to provide 27,000,000 hp. by 1975. Power must be considered an important component for electrolytic reduction of aluminum oxide to the metal form.
- *Low-grade Fuels:* Washington, Oregon, Idaho, and British Columbia possess tremendous quantities of low-grade fuels and ores—zinc, lead, silver, gold, copper, and coal. British Columbia alone produces over 80% of the zinc mined in Canada.
- *Natural Gas:* Petroleum and natural gas are available for refinery and industrial use by pipeline from British Columbia and adjacent provinces.
- *Fisheries, Agricultural Products:* Pacific Coast residents are familiar with fishing activities in the Northwest—salmon, halibut, herring, and crab. From the inland valleys and plains comes a flow in great profusion of wheat, barley, and other grains, tree fruits and berries, and vegetables.
- *Water Transport:* Transportation is readily available from deep-water ports, transcontinental railroads, and, for speed, time-saving, and emergency situations, there are available major air lines capable of reaching almost any place in the world.
- *Climate and People:* But just as important as any of the foregoing factors are the climate and the people. Here is a climate mild in nature, but devoid of the wide, severe changes that hinder or prevent year-round operation. As employees in industry, the inhabitants of this region enjoy the highest wage level to be found anywhere and, in support of such standards, they have established an extremely high rate of productivity and a high degree of efficiency.

ROLE OF CHEMICAL ENGINEER

The chemical engineer participates in the design work, but more important is the vital part he must play in operations, improvements, and changes in processing to meet competition. Specifically what can he do? His aim should be:

- **to take a leading part in the program to reduce wastes and to convert the same into marketable products**
- **to place in operations new processes for converting timber to cellulose and silvichemicals**
- **to develop new procedures for extracting chemicals and heat values from low-grade fuels**
- **to provide ways and means for more intensive utilization of agricultural products and fishery resources**
- **to find new and better ways of converting power into aluminum and other metals.**

Thus, it can be deduced that in the Northwest are all the necessary ingredients for a successful industrial growth.

And this is where we should pause for a moment and analyze the situation. The great mistake that man has often made has been that of casual acceptance of his position. Such thinking held back the needed industrial development of the South, slowed the development of the West until World Wars I and II, forced the tapping of its raw materials, stifled individual enterprise in Mexico, a country rich in raw materials.

Distance Lends Disenchantment

But the tremendous resources of this region are at a great distance from centers of consumption. This is a severe handicap when you recognize that the distance from the markets must be measured in terms of cost to move goods and not just in miles. The resources of the Northwest, whether in the primary stage or secondary stage of manufacture, must be moved to the market and unfortunately the market is not in the Northwest.

A point which throws some light on the contrast between the East and the Northwest should be noted. The population and the projected growth show that the gains in the Northwest (Washington, Oregon, and Idaho) from 1956 to 1975 presumably will be 1,644,000 and in the East (New York, New Jersey, and Pennsylvania) from 1955 to 1975 will be 9,486,000.†

It is only logical to assume that those who come from other areas of the United States as representatives of key industries and specifically of important chemical companies starving for growth and expansion would not want to miss out on the potential of industrial growth in the Northwest because of the population-time factor.

It seems that this territory cannot indulge in the comfort of lassitude and just wait for the growth of markets within its own area. The largest and fastest growing markets in the world in terms of population are at the doorstep of the Northwest through low-cost, Trans-Pacific transportation by sea—Japan, India, China, Indonesia. One would also logically single out Southern California, where the population is growing faster than in any other area of this country.

And what are the future needs of these countries and areas? What will they buy? How will they alter and

(Continued on page 8)

* Mr. Sheehy is executive vice-president of Rayonier. This article is based on an address given before the Seattle National Meeting of A.I.Ch.E. on June 10, 1957.

† Seattle-First National Bank, Economic Research Department; U. S. Bureau of the Census; Stanford Research Institute: Economic Unit of USN&WR.

Noted and quoted

(Continued from page 6)

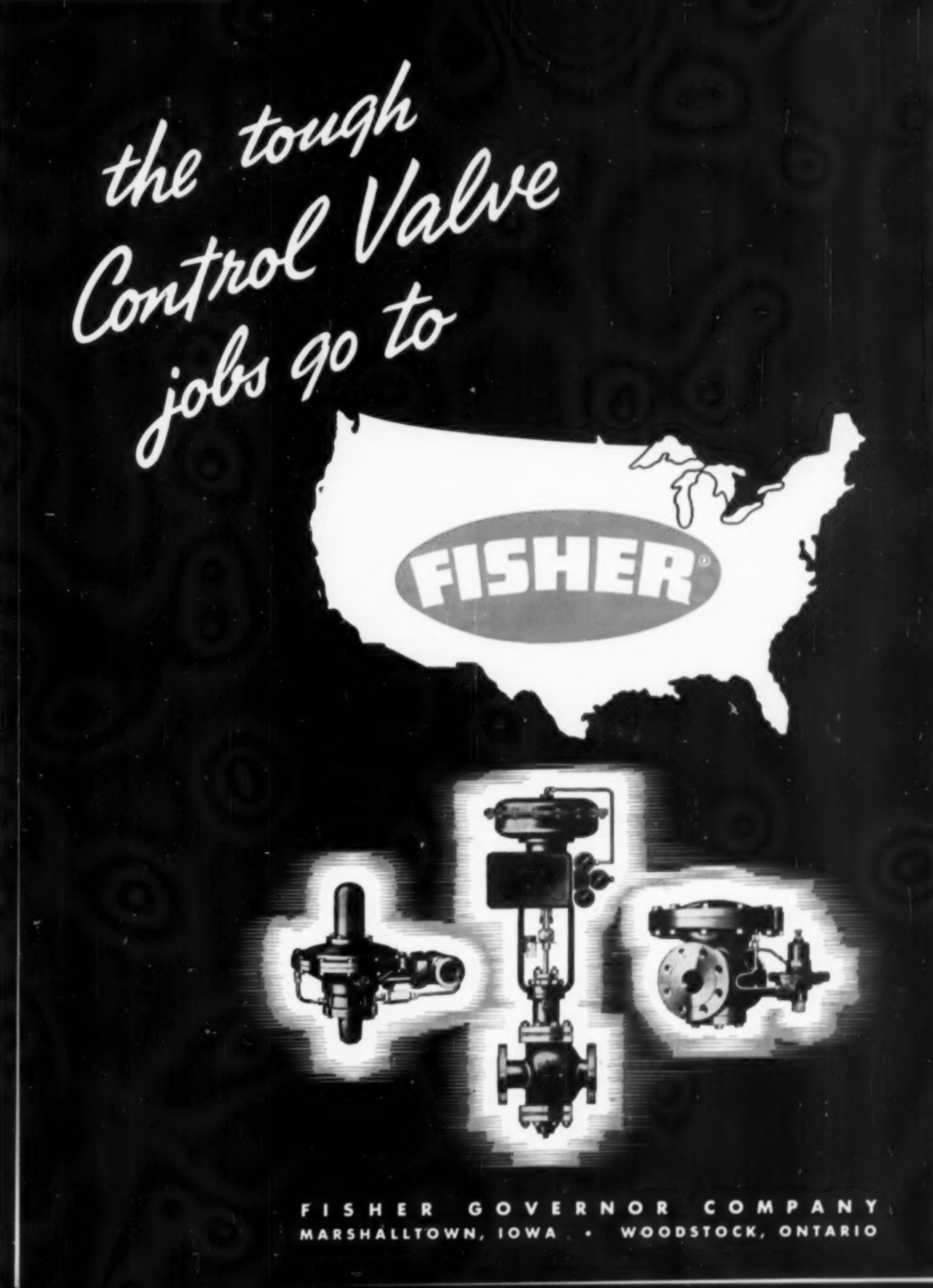
improve their industrial systems to meet the clamoring demands of an already gigantic population that is growing daily at a faster rate even than ours here in the United States?

Americans, and American businessmen in particular, have been slow to grasp the opportunities in foreign trade. Regardless of one's political inclinations, the fact is that the United States and Canada are up to their necks in world affairs and no one can foresee a withdrawal from their participation in the economic and political affairs of the rest of the world. The American soldier in World War II, and today, is the greatest revolutionary force that the world has ever seen. Literally billions of peoples in the more backward areas of the globe were content for generations to live a life of meager subsistence until they saw the ordinary American, as represented by American servicemen, living on a scale that once befitted only the lords of the land. The well-dressed, well-fed North American with his air of confidence and his bearing of self-respect showed that the average man, even in the most remote corner of the world, could live in dignity, in health, and well-being. And this simple fact has created an enormously powerful urge among the economically suppressed peoples to emulate him.

We thus find in the peoples of Eastern Asia a deep-seated and powerful drive to industrialize, to grow, and to attain at least some of the blessings of the modern, materialistic economies. And this drive has already produced a list of wants which the Northwest area, in part, is able to provide and thereby assure its own economic health and growth.

Peoples in the Far East need clothing and we can help provide it through chemical cellulose to make rayon and related synthetic fabrics; they need shelter—and here too our forest industries can go far toward meeting their wants; they need metal products of all kinds and descriptions; they need heavy machinery, road-building equipment, railroad equipment, in order to build the capital installations required to further their industrial growth; they need food—wheat, barley, fruits of all kinds, and the high protein foods from the sea. These, too, the Northwest can best supply.

I predict that there will be no shrinking of demand or opportunities for the abilities of the chemical engineer in this area. Instead, it is questionable that the demands for such abilities can be filled.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Letters to the editor

EXPRESS YOURSELF AT THE CHICAGO MEETING

This letter is addressed to those who prefer to express their views on chemical engineering subjects before small discussion groups, and who would be interested in making known (in advance) their desire to talk freely on specific subjects at the forthcoming Chicago National Meeting (December 8-11).

The idea of discussion groups is not novel, since it has been tried at some Institute meetings in the past. Several years ago it was tried at Kansas City with some success and a repeat performance at Seattle in June brought forth many favorable comments.

As to possible subjects, one might, for example, consider Cost Control as the subject of one of our symposia. With rising costs and competitive pressures to hold down prices, the squeeze is on. We have our problems; few people in industry don't have situations where "two heads are better than one." On the other hand, Laboratory and Pilot Plant Techniques is one right down your alley. Do you want to know more about protecting your pilot plants against hazardous conditions? Maybe you are proud of the way you have met a certain problem and want to pass the information on to others. The possibilities of participation are limitless—catalytic reforming, alkylation, isomerization, octane numbers. The petroleum industry must be ready for the future. What is the most economical means of getting the next octane number? TCP and other additives—do they help performance? Here is your opportunity to thrash it out.

Based on experience it appears that a group of thirty to fifty people would be about right for this type of discussion. Each person should then have an ample opportunity to express his opinions on the subject under consideration. No definite pattern will be devised to inhibit or limit the discussion, but instead free interchange of ideas moving in any direction desired by the group will be the order of the day. No attempt will be made to monitor or transcribe the discussion.

A subject would be selected in advance for a particular group, and it might (or might not) have a connection with the symposia being presented at the meeting. The subject might be broad or narrow, depending upon the interests of the group.

For the Chicago Meeting the Program Committee is planning to conduct these discussion sessions on a considerable scale. We hope that by so doing we will not only provide another medium for exchange of knowledge, but also determine the desirability of holding such sessions in the future through comments on the value of these sessions by the engineers attending. In order to make these *your* sessions, we are definitely interested in hearing from those members of the Institute who are interested in the idea. We would like to receive your thoughts on participation, make-up, and subject matter. This is an open invitation to all members of A.I.Ch.E. and a direct challenge to those members who are planning to be with us in Chicago in December. If you have any problems, this might give you the opportunity to find a solution. If you have any ideas you would like to discuss, this will give you an opportunity to present these ideas without preparing a paper. Regardless, it is an opportunity for you to participate in the planning of something from which you may benefit.

Please address your letter suggesting a discussion subject to the undersigned as soon as possible. Just say: "I would be interested in talking about ...." (you fill in the subject).

Henry F. Nolting
Technical Program Chairman
Chicago A.I.Ch.E. Meeting
December 8-11, 1957
Standard Oil Co. (Indiana)
Whiting, Ind.

WHAT IS THE NATIONAL MEMBERSHIP COMMITTEE ALL ABOUT?

In response to a number of questions asked from time to time about the Institute's current drive to get more applications for membership, J. J. McKetta, chairman of the Membership Committee, has prepared the explanatory statement which follows:

—Editor

• What Is the Purpose of Our Membership Committee?

The primary purpose is to contact nonmember chemical engineers (who are qualified for some grade of membership) and to convince them that they should become members of A.I.Ch.E. It must be emphasized that even with a vigorous membership drive going on, the Institute is still maintaining its high level of requirements for admission.

There are over 80,000 chemical engineers in the United States. Less than 20 per cent of them are members of A.I.Ch.E. Our job, then, is to increase this percentage to a significantly higher figure.

What we have been doing is two-fold:

(a) Getting the names of all nonmembers in each section of the United States who are qualified for a grade of membership. So far we have turned in over 8,000 names of nonmembers to the A.I.Ch.E. office. F. J. Van Antwerpen or the President of A.I.Ch.E. (or both) will contact each of these nonmember prospects by mail.

(b) After we have these names, our committee members make a personal contact with each prospect. He is advised of the purpose of A.I.Ch.E., the advantages of being a member, future plans, etc.

With this two-pronged attack we are making considerable headway and our membership drive is yielding fairly good results.

• What Is the Aim of the Membership Committee This Year?

Our goal for 1957 is 2,000 new applications. Last year we obtained 764 applications, and in 1955, 639. So far this year we have 630 new applications—up to the end of June. We still feel that we can make our goal of 2,000 by January 1, 1958.

• Why Should the A.I.Ch.E. Be Interested in Getting More New Members?

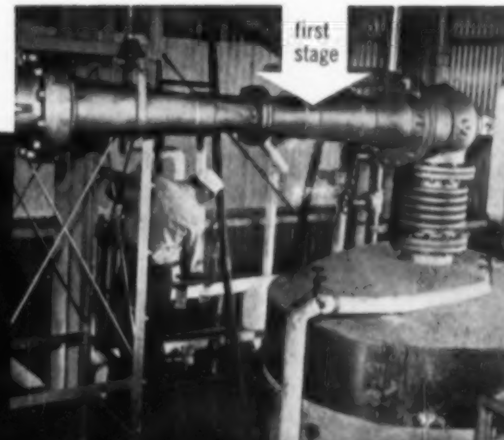
You may ask yourself the question, "Don't we already have enough members?" The answer is, "Definitely no!" The A.I.Ch.E. is striving continuously to benefit its members and to be of more service. Much progress has been made recently; more is being planned. Long-range plans regarding the future of A.I.Ch.E., which will benefit each of us professionally, are based on the normal, and expected, rate of growth. Increased services, naturally, are more costly—more money must be expended. At the same time, the A.I.Ch.E. *should* represent a larger percentage of the total number of chemical engineers in the country.

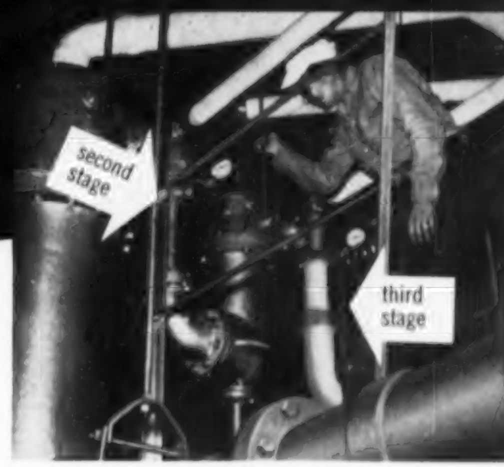
• How Is the Membership Committee Organized on a National Scale?

We have two vice-chairmen. W. Henry Tucker, Purdue University,

(*Continued on page* 14)

this ELLIOTT three-stage EJECTOR maintains absolute pressure of 0.25 in. Hg in deodorizer



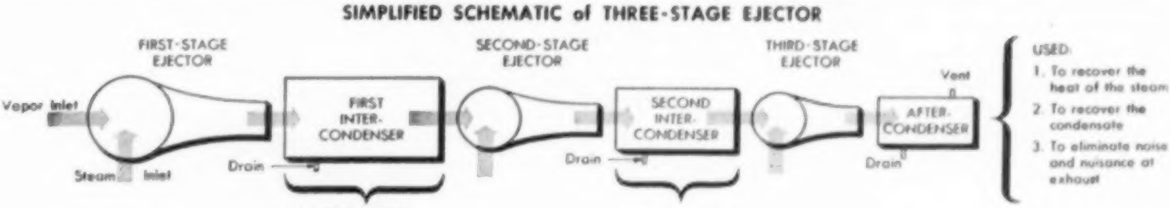


This typical installation serves a continuous lard deodorizer that deaerates, heats, deodorizes and cools in a single vessel. Function of the Elliott three-stage steam jet ejector is to continuously maintain an absolute pressure of 0.25 in. Hg throughout the entire deodorizing vessel.

The first or booster stage seen in the upper photo, compresses stripping steam and discharges to a barometric-type booster condenser, where both motive and entrained steam are condensed. The lower photo shows the second-stage and third-stage ejectors with intercondenser, which compresses noncondensable gases to atmospheric discharge.

The installation illustrates Elliott's wide experience in designing and building multi-stage ejectors for process industry applications. Three-stage ejectors—such as in the schematic hook-up below—are usually applied where an absolute pressure from 1.00 to 0.10 in. Hg is required. Condensers may be either barometric or surface type. For more than 40 years, Elliott steam jet ejectors have proved themselves—again and again—to be a simple and dependable method of maintaining low absolute pressures. Consult with the Elliott ejector specialist at the nearby district office about your requirements, or write Elliott Company, Jeannette, Pennsylvania.

SIMPLIFIED SCHEMATIC of THREE-STAGE EJECTOR



ELLIOTT Company

Ask for ENGINEERING DATA which covers the complete range of Elliott steam jet ejectors including single-stage, special corrosion-resisting, and various multi-stage types.

G7-1

Letters to the editor

(*Continued from page* 12)

[now with Shell Chemical] held the spot as educational vice-chairman for the past two years and he is the hard-hitting one who should get all the credit for the great increase in new members from the graduating seniors. Henry's committee is made up of the student councillors of each of the student chapters throughout the country. He is in constant contact with these men. His aim is to make sure that we get at least 50 per cent of the graduating seniors to become members (last year we got 17%). With all the hard work he is doing we will have that goal this year.

E. M. (Matt) Jones, Monsanto Chemical Company, is the ramrodder and the vice-chairman of the industrial portion of our committee. Under Matt we have one man from almost each local section of the country on our committee—about 58 members. On the local section level, each man on our national committee acts as chairman of his separate local membership committee. In some sections there are as many as 130 members on a local membership committee.

• How Can Each Member of the A.I.Ch.E. Be of Help?

If each member of the Institute would give us only one hour of his time for the year, during this hour he would be able to contact a qualified nonmember and tell him the advantages of joining the A.I.Ch.E. Or, why not take a nonmember as your guest to the next local section meeting? Just imagine what would happen if only one half of the membership were successful in that hour! We would appreciate such efforts by all our members. A.I.Ch.E. will be better for each of us only if we members work hard to make A.I.Ch.E. better.

• Who Are the Members of the Membership Committee?

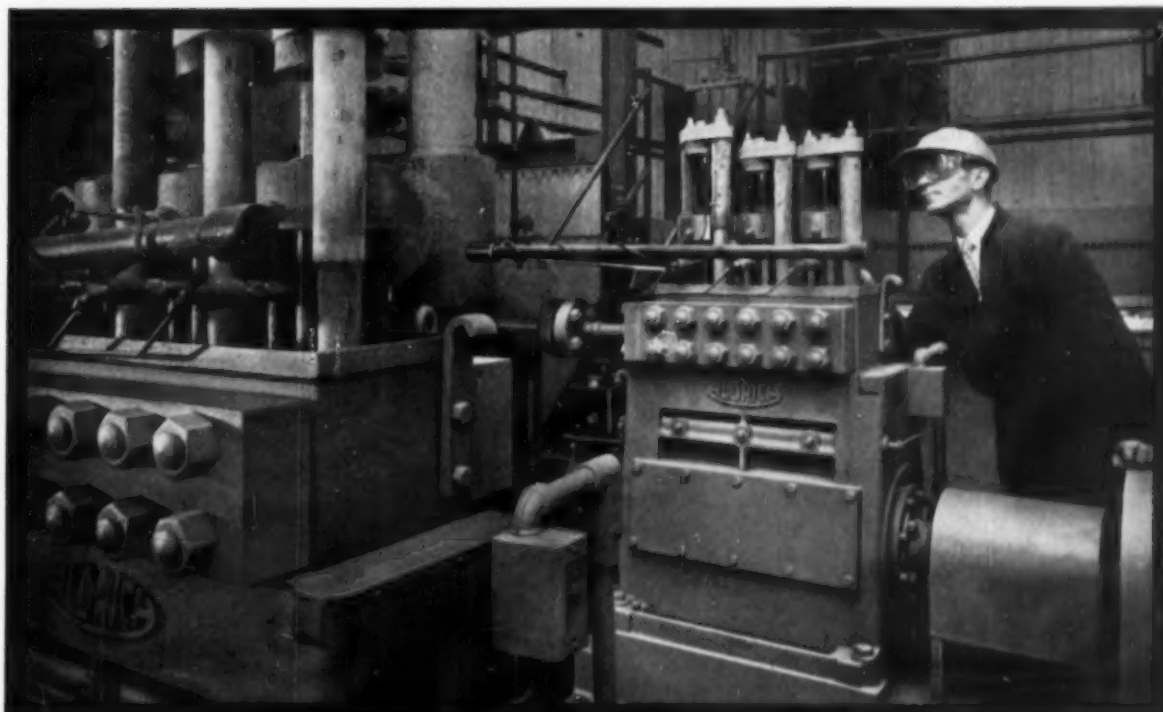
The list of members appears in the annual supplement to the 1954 yearbook. These men have given the A.I.Ch.E. many, many hours of hard unselfish work on membership matters. If you would like to join their local committee, or if any member would like to contact their local man, they are welcome to do so.

John J. McKetta
Chairman, A.I.Ch.E. Membership Committee
Department of Chemical Engineering
University of Texas
Austin, Texas

SPENCER CHEMICAL CO. UNRAVELS KNOTTY PROBLEM:

Maintaining a controlled flow of liquid ammonia at high pressures, 24 hours a day.

At the Vicksburg, Miss. plant of Spencer Chemical Company, ammonia production demands two things of pumps: (1) 24-hour, 7-day-week operation and (2) continuous flow of controlled volumes of liquid ammonia at high pressure.



How Spencer licked the problem: When Spencer began outlining construction plans in 1951, company engineers specified two Aldrich Direct Flow, $\frac{3}{4}$" x 3" stroke Triplex Pumps. These were scheduled to be used for alternate 30-day periods. According to company spokesmen, nearly four years of service have proved these pumps to be efficient and capable of durable service.

Results: Dependability and freedom from trouble in all phases of operation. The Vicksburg Works Maintenance Superintendent tells us: "The Aldrich Pump is an excellent unit. Valve life is excellent and packing life exceptionally good."

We'll be glad to send you full information on Aldrich Pumps and their advantages to you. Simply write Aldrich Pump Company, 20 Gordon Street, Allentown, Pa.

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WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specification of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 888 Poplar Street, Le Roy, N. Y.*

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Lapp

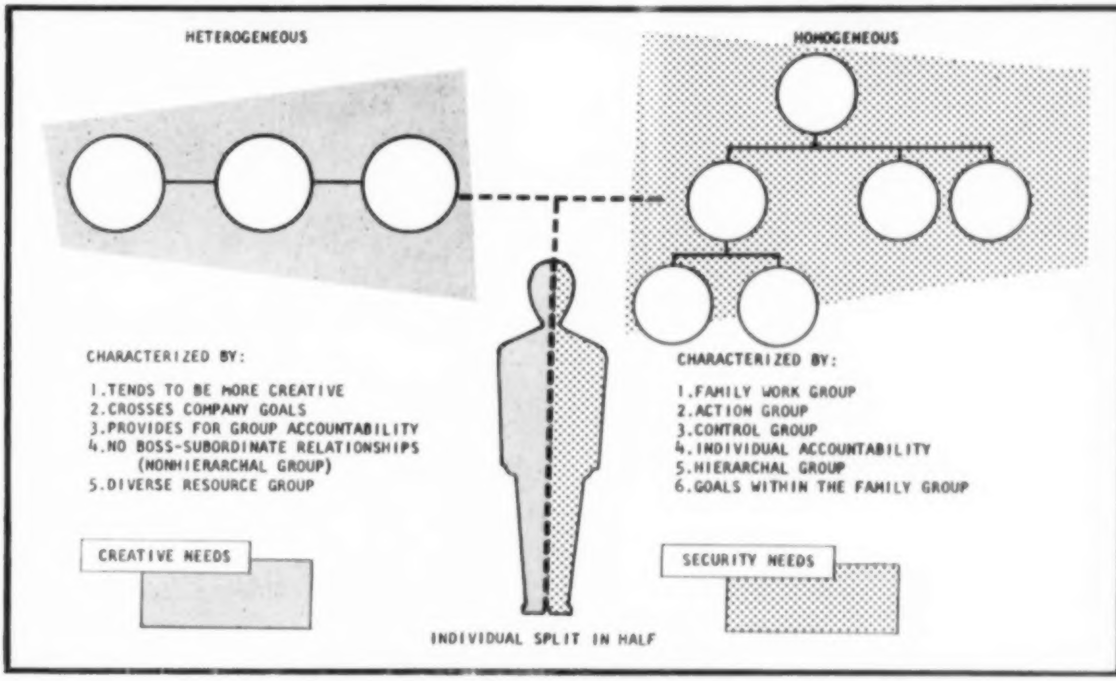


Fig. 1. This Flexible Grouping structure provides creative solutions to company problems

TEAMWORK IN PRODUCTION PLANNING

C. C. VanderWall | Ansul Chemical Company, Marinette, Wisconsin

Who can be creative and make his creations productive? None other than the engineer and the scientist! In the accompanying article the author suggests that industry supply both the theory and experience if it is desirous of providing the climate necessary for creativity and thus to expect the maximum use of the talents of its engineers.

In Webster's "New International Dictionary" the word *creative* is defined as *productive*. All in industry would probably agree that being creative is being productive. However, the reader is probably saying to himself, "That's fine, but I have a job in industry; I have to produce—I am not a writer, composer, musician, or interior decorator." Yet, given an opportunity, the jobholder can be creative in his work.

The opportunity to be creative in industry is no pipe dream. It can be a reality and a number of companies have combined theory with practice to provide this opportunity. A case in point is the Ansul Chemical Company and specifically the way product planning is handled there.

In order to put this story in its proper framework, it is necessary to know a little about the company, its products, philosophy of management, and the product planning procedure as it relates to engineers, executives, and scientists.

In business since 1914 and located at Marinette, Wisconsin, Ansul's products are both chemical and mechanical in nature. Its manufacturing facilities are located in Marinette, although its products are distributed in sixty countries by both its own sales force and selected distributors. There are approximately 500 employees in the organization.

To succeed under a competitive system, the management has isolated and labeled certain basic business principles and has listed its primary responsibilities as follows:

- To assure survival of the business, its profitability, its markets, and its products.
- To make the most effective use of the company's human resources.
- To provide adequate succession to management.

Analyzing these principles, the company further considered that the second item, namely the effective use of human resources, was of the greatest

TEAMWORK . . .

(Continued from page 19)

importance. If this is accomplished, management reasoned, the survival of the business and adequate succession to management will be assured.

Thus, in the beginning, it was decided that the practical way to make the best use of human resources was through the participative management approach ". . . which is a way of managing a business enterprise aimed at unleashing the full creative power of people through their participation" (R. C. Hood, president of Ansul).

Since 1950 the company has operated under certain principles which determined management behavior; some of these are as follows:

- **People actively support what they help create.**
- **Decisions should be made at the lowest possible level.**
- **Participating in goal-setting builds motivation, leads to effective implementation and increased human efficiency.**
- **People, not products, are the real competitive difference between companies.**

gives the individuals a creative group and a work family or action group—both contributing significantly to the end result. Both heterogeneous and homogeneous factors must be present if the model is to be truly effective.

In the company, the subject of this study, product planning is a total company responsibility, not that of the research and development group alone. Applying the flexible grouping model to product planning, the organizational setup would be as follows:

A Coordinator of Product Planning maintains over-all control and provides implementation to the product program.

The main line of product planning effort is directed by the *Product Planning Policy Committee.* This policy group is made up of the following people: president; assistant to the president (who is secretary to the group); coordinator of product planning; vice-president of sales; treasurer; vice-president of research and development; director of manufacturing.

The subjects considered by the Product Planning Policy Committee are suggested by two screening committees: *New Product Screening Committee* and *Modified Product Screening Committee.* Members

area, by skill and knowledge, and by name. People on the roster know why they are listed and where. They are selected for the roster by their area heads.

It is again important to recognize that the same people who do the investigating (members of PIT's, for example) and who make the decisions (such as the members of the Product Planning Policy Committee) play dual roles in the company. The policy group is made up of area heads who are responsible for seeing that the job is carried through; the investigation teams are active members of the area heads' staff and are, in most cases, the ones who will carry out the technical work necessary to produce the product. *The same people who participate in the planning are also responsible for the actual work!*

Examples of some of the tasks are quoted from actual assignments:

- **The objective of Product Investigation Team No. — is to establish a stepwise program with deadlines to make and market test mechanical product .**

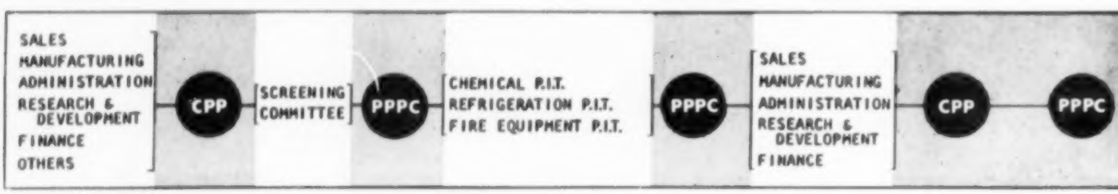


Fig. 2. Organizational format for new product coordination. Coordination among P. I. T. groups and among area heads, both on a project and between several projects, is the responsibility of the C. P. P.

With full appreciation of the fundamental dignity of man and a real confidence in human beings, management began to train itself and to study the involvement of all its people so that a favorable, creative climate or atmosphere could be established and maintained. A starting point was the furnishing of total information and full communication about *all* company operations to *all* levels of the organization. Under these conditions a group of managers and professional people were developed who know they are functioning in a group whose goals are creative ones. This was not done without *unlearning* some of the autocratic processes previously in operation.

Since the growth and survival of any company depend upon getting *more* creative solutions to its problems (people solve problems) Ansul developed through experience and application of theory a model which is used in many different ways, and which is termed Flexible Grouping. It is illustrated in Figure 1. This structure

of the New Product Screening Committee include: vice-president in charge of research; coordinator of product planning; technical director.

Members of the Product Modification Screening Committee are: technical director; coordinator of product planning; divisional heads of manufacturing and sales; purchasing agent.

The basic data upon which the Product Planning Policy Committee makes decisions develop in product investigation teams, the tasks given these teams being assigned by the Product Planning Policy Committee.

The Product Investigation Teams vary in accordance with the problem to be solved. They are made up of those people (including outside consultants) most qualified to assist in finding solutions to individually defined problems.

A record of inventory resources available is kept constantly up to date by the coordinator of product planning. It is called the PIT Roster. The roster identifies people in the company (and outside consultants) by

- **The task of Product Investigation Team No. — is to:**

  (a) establish the desirability of merchandising a type — fire extinguisher; (b) if it is determined desirable, establish a complete stepwise program to manufacture and sell; (c) report recommendations with alternates to Product Planning Policy Committee by —.
- **The task of Product Investigation Team No. — is to establish the desirability of the company's making and selling chemical product —. If desirable, accumulate data, evaluate, and recommend a stepwise program with Gantt charts for manufacture and sale of chemical product —.**
- **The task of Product Investigation Team No. — is to accumulate, evaluate, and recommend to the Product Planning Policy Committee what products and services are needed by industrial consumers of safety equipment. This study is not limited to the present production or distribution facilities.**

One of the big pluses of the flexible grouping model is that it allows creativity not only in the top jobs, but also all the way up and down in management. But the real core of the use of the model for most scientists and

(Continued on page 22)

TEAMWORK . . .

(Continued from page 20)

engineers is in the make-up of the Product Investigation Teams, more commonly known as PIT's.

Product Investigation Teams

What are the characteristics of a typical PIT? Who makes up a team? Who sets team goals? How are team needs taken care of? Individual needs? How is the communication pattern, internal-external? Any side effects? Problems?

- **Membership**
  - a. selected for specialized skills as related to task of team by area head (membership tied to individual's job description and performance evaluation)
  - b. no "boss-subordinate" on same team
  - c. no Product Planning Policy Committee member on team
  - d. representation from all areas of company related to task
- **Goals**
  - a. team goal established by Product Planning Policy Committee
  - b. internal goals to meet team goal established by team members
  - c. individual goals met in peer relationship
- **Team Needs**
  - a. need for more efficiency met by a special meeting skill development clinic for all members
  - b. redefinition of objectives by Product Planning Policy Committee where necessary
  - c. good job, if done, recognized by Product Planning Policy Committee
- **Individual Needs**
  - a. provides process for getting own ideas "into mill"
  - b. can voice opinions freely
  - c. creative atmosphere in peer relationship
  - d. minority report accepted by Product Planning Policy Committee if presented
  - e. tied to reward system of family group
  - f. individual makes a difference
- **Communications**
  - a. recorder-convener selected by group
  - b. written reports of all meetings to Product Planning Policy Committee and other team members.
  - c. interaction between individuals is free because of lack of superior
  - d. understanding of other fellow's job increased — knowledge of problems in other areas.

Just how does a typical professional resource—for example, a chemical engineer in manufacturing—become a member of a PIT? What is expected of him by his boss? What are the company's expectations? What is his commitment to the PIT and to his family work group? How can he best use his specific skills?

One can consider here a PIT that is being developed for a chemical product (see Figure 2) identified and spelled out by the Product Planning Policy Committee. The coordinator of product planning and the area head (for example, the director of manufacturing) would select the best resource listed in the roster from the manufacturing area. It may be a particular chemical engineer, but generally there is an alternate. This is communicated to the engineer by the coordinator of product planning (his immediate supervisor being first checked).

The chemical engineer is now in a PIT, the average number of any team being five or six members. He, with the other members of the team at the first meeting, listens to the task as outlined by the Product Planning Policy Committee and clarified by the coordinator of product planning. He appoints a recorder-convener, who is assigned jobs for accumulation of data from manufacturing. He may attend ten to twenty meetings, each one or two hours long. How does he handle his "other" work? How does he operate in his family work group? The answers to these questions depend largely upon the training and skill of the individual.

There have been, and still are, problems that are handled by the flexible grouping method. In PIT such questions arose as who was making decisions for the company; how was one to stick to the task, and many others. But the positive results tell the story and include some compelling facts:

- **To date more product ideas are on tap than can be adequately financed.**
- **A modified product has been put out in three months vs. the six to nine months estimated.**
- **Plans are being made for putting new products out in nine to twelve months vs. the eighteen to twenty-four months previously estimated.**
- **New managerial talent has been uncovered.**
- **The staff has developed a greater understanding of broad corporate objectives.**

In conclusion one might say that the company discussed in this article agrees rather literally in its production planning procedure with Webster, who defines teamwork as "work done by a number of associates all subordinating personal prominence to the efficiency of the whole."

Presented at A.I.Ch.E. meeting, White Sulphur Springs, West Virginia.

ADVERTISEMENT—*This entire page is a paid advertisement* Prepared by U. S. Industrial Chemicals Co.

U.S.I. CHEMICAL NEWS

August ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1957

Chemical Polish for Pure Zinc Improved With Ethyl Alcohol

An improved polish for zinc, consisting of nitric acid, ethyl alcohol, and hydrogen peroxide has been developed by a leading research laboratory.

Immersion of pure zinc for about two minutes in a bath of these chemicals is said to produce a high and lasting luster that resists rapid oxidation up to temperatures of around 660°F in air or in a sodium-potassium nitrate salt bath.

The role of ethyl alcohol in this polish appears to be that of a moderator of the nitric acid. Although polishes composed of other chemicals have been used for zinc, the nitric acid-ethyl alcohol-hydrogen peroxide polish is said to have longer life and to produce on the zinc a thinner oxide film of increased stability.

It is recommended that users prepare the polish fresh daily. *Caution:* ethyl alcohol should never be poured into nitric acid; the reverse, however, may be done safely. Interested readers who wish detailed assistance may call on U.S.I.'s technical service staff.

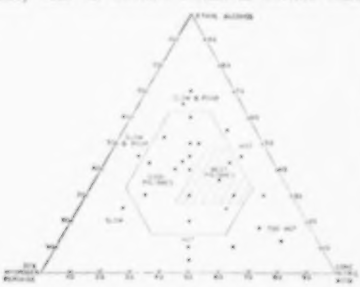


Diagram illustrates chemical polishing baths for zinc, based on 2 min. immersion time. (Diagram from "Journal of Metals.")

New Centrifuges Underscore Titanium Strength

High speed centrifuges fabricated with an aluminum-vanadium alloy of titanium now are in operation on an experimental basis. They are reputed to run 28% faster than stainless, with no greater working stress in the bowls.

Steady increase in such applications of titanium is expected – namely, where high strength-weight ratio as well as corrosion resistance is needed. Titanium now can be alloyed, welded, and bonded with chrome (U.S.I. Chemical News, May, '57). With three times the strength of aluminum, but only half the density of steel, titanium has been in heavy demand for aircraft components subject to severe resonance conditions.

U.S.I. is building a titanium sponge plant at Ashtabula, Ohio, which is expected to go on stream late this year. This modern plant will employ a sodium reduction process, and on the basis of present figures will turn out high purity titanium sponge at lower cost than any other existing commercial technique.

Organosodium Compounds Open Way to Economical Synthesis of Many Organometallic Compounds

Higher Yields Than with Conventional Grignard Reagents; Safer, Simpler Processing Among Advantages Cited

Many organometallic compounds can now be synthesized economically and safely from organosodium compounds, according to a paper recently presented before the American Chemical Society. In some cases the latter compounds can be used as intermediates to prepare an otherwise hard-to-make Grignard reagent. In others they can be reacted directly with metal halides to form new carbon-metal bonds.

Grignard reagents, compounds of magnesium with an organic halide, have long been standard building blocks for synthesizing organometallic compounds. However, from the commercial standpoint many Grignard reagents are difficult and hazardous to prepare, some require costly iodides or bromides as starting materials, and yields of desired organometallic compounds are frequently disappointing.

Among the advantages of organosodium compounds cited by the investigators are high yields and safety and convenience in handling.

For example, phenylsodium reacts with boron trichloride to form triphenylborine in 70% yield. Benzylsodium and phosphorus trichloride produce tribenzylphosphorus in 84% yield. Also, in this whole class of reactions, sodium as a starting material is more economical than the magnesium of typical Grignard reagents. Finally, reactions proceed in a hydrocarbon medium, thus eliminating the hazard of storing and handling large quantities of ether, the solvent used with Grignard reagents.

Reactions of RNa Compounds

The route to organometallic compounds from metallic sodium employs two general reactions. In the first an organic halide is reacted with sodium to produce an organosodium compound:

$$RCl + 2\ Na \rightarrow RNa + NaCl$$

This product is then reacted with a metallic halide to yield the desired organometallic compound:

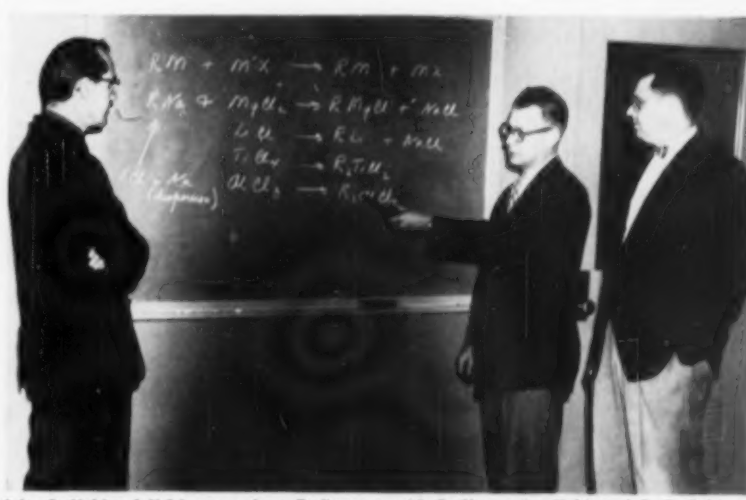
$$RNa + MgCl_2 \rightarrow RMgCl + NaCl$$

Organosodium compounds may react with the halides or alkoxides of lithium, magnesium, mercury, boron, aluminum, silicon, germanium, tin, lead, titanium, zirconium, phosphorus and iron.

Sodium Dispersions Key Factor

The recent introduction of simple and safe techniques for laboratory or plant preparation of finely dispersed sodium has stimulated wide interest in the use of organosodium compounds. Hansley's studies on preparation

MORE



John F. Nobis of U.S.I. research staff discusses with F. Moormeier (left) and R. E. Robinson (extreme right) equations for reaction of organosodium compounds to form various carbon-metal bonds. They presented a paper entitled "Use of Organosodium Compounds for Preparation of Other Carbon-Metal Bonds," at the Spring meeting of the American Chemical Society.

August ★ **U.S.I. CHEMICAL NEWS** ★ 1957

CONTINUED *Organosodium*

and use of finely dispersed sodium (10-30 μ) to produce phenylsodium in 90% yields* opened a new era in organosodium chemistry.

Extensive research in U.S.I. laboratories shows that phenylsodium and benzylsodium can be made by carefully controlled conditions which include the presence of a slight excess of freshly dispersed sodium. The reaction between chlorobenzene and sodium under these conditions is immediate and complete: one mole of phenylsodium can be prepared in only 20 minutes. This reaction is easily adapted to larger scale and is now being used industrially.

The largest commercial plant utilizing organosodium compounds will soon be in operation at Tuscola, Illinois where U.S.I. is using disodiooctadiene, made directly from butadiene and dispersed sodium, to produce U.S.I. Isosebacic® acid, a mixture of 10-carbon dibasic acids.

(A new brochure on the preparation of sodium dispersions is available from U.S.I.)

Advantages of Organosodium

Until practical techniques for making sodium dispersions were developed, the reaction of an organosodium compound with magnesium chloride to produce a Grignard reagent had no commercial value. In general, it was easier to prepare Grignard reagents than the corresponding organosodium compounds. Now, however, there are cases where organosodium compounds can be made from starting materials which yield Grignard reagents only with difficulty. For example, organic chlorides react very sluggishly with magnesium, but yield organosodium compounds quite readily.

As a result, many Grignard reagents which have been prepared from expensive iodides or bromides can now be obtained from the cheaper chlorides, often in higher yields than are possible by the former method. Other organosodium compounds, synthesized by reactions which are completely unknown in the field of organomagnesium chemistry, can now be converted to hitherto unattainable Grignard reagents.

*V. L. Hansley, *I&EC* 43, 1759 (1951)

Cube-Shaped Polyethylene Containers for Corrosives Promote Lab Safety

An ingenious new container gives laboratory workers an almost accident-proof way to receive, store and dispense corrosive reagent chemicals.

The package consists of a cube-shaped polyethylene vessel inside a double corrugated paperboard box which serves as a shipping carton. The user need never remove the polyethylene cube from the box; the latter has a slotted opening for a pouring mouth on the cube and a pull-out safety grip for easy handling.

The new container is now being used by a leading manufacturer of reagent chemicals for packaging solutions of sodium hydroxide and potassium hydroxide in 1-gallon size.

It is light, unbreakable, and the unique design makes it convenient to dispense the contents. An economy feature is that no deposits are required, and there are no empties to return.

Polyethylene "Coating", "Lamination" Defined

An industry standard adopted by the National Flexible Packaging Assn. defines the difference between "coating" and "lamination", as these terms are applied to polyethylene packaging.

A coating is "a substance deposited while in a liquid state on a web without the use of adhesive means between the combined materials". Lamination is "the combination of two or more webs by the use of an adhesive layer between the webs".

Coating is the more common method. U.S.I. PETROTHENE 203 is a polyethylene resin that is widely used for this application.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U. S. I.

New adhesives for labels feature resin emulsion glue which penetrates silicone layer to bond on the glass surface. The adhesives feature controlled tacking in clear non-staining micro-thin films which are noncrystallizing, says company. **No. 1260**

A pamphlet on titanium tubing offers information on size range and tolerances and mechanical, physical and working properties of tubular titanium. **No. 1261**

A new remote control baffle for fume hoods is operated from an outside control panel. Manufacturer claims baffle can be quickly adjusted for any desired air flow aperture without interrupting work or exposing personnel to injury. **No. 1262**

A double acting rust remover is said to remove light rust in a few minutes, heavy rust in one to two hours. Deposits a rust-inhibiting film as it works, requires no rinsing of treated metal. **No. 1263**

A new booklet entitled "Zirconium and Hafnium" is now available. It covers in detail the mechanical and physical properties of the materials as well as general methods of fabrication and corrosion resistance. **No. 1264**

A new vinyl paint is said to achieve 5 to 8 times the film thickness per spray pass as other vinyl paints. Supplied in 8 colors, it is also said to be fast drying, easy to apply, economical, corrosion-resistant. **No. 1265**

Deuterated solvents and organo-metallics of high isotopic purity are now available in experimental quantities, with a wide range of research applications, including NMR spectroscopy. **No. 1266**

Color dispersion and intensity in plastics are said to be improved by a new extender. This product is also reported to increase lubricity, mold-release, and brightness of finish in many plastics. **No. 1267**

A continuous water vapor recorder determines low concentrations of water vapor in air or gas streams by measuring heat energy exchanged in adsorption or desorption. Designed for pipe lines, drying towers, feed streams. **No. 1268**

An external manipulator for tubing applies pressure externally on a flexible tube, producing a continuous, metered flow of liquids which can be as low as 0.1 cc. per day, according to the maker. **No. 1269**

A detector kit, small, compact and practical, rapidly determines low concentration of vapors of toluene diisocyanate and toluene diisocyanate urea. Said to be especially useful in plants making polyurethane plastics. **No. 1270**

Marginal notes

What to do When Attacked by a Differential Equation

Applied Mathematics in Chemical Engineering, Second Edition. Harold S. Mickley, Thomas K. Sherwood, and Charles E. Reed. McGraw-Hill Book Company, Inc., New York, N.Y. (1957) xii + 413 p., $9.00.

Reviewed by W. H. Corcoran, California Institute of Technology, Pasadena.

Chemical engineering, generally speaking, is concerned with studies and economic applications of ideas in energy transfer, material transfer, momentum transfer, chemical equilibria, chemical kinetics, and properties of materials. Evaluation of a book on the applications of mathematics to chemical engineering must be on the basis of how, with respect to current knowledge and needs, it will help the chemical engineer properly attack the stated fields of interest. Professor Mickley's second edition of "Applied Mathematics in Chemical Engineering," prepared with assistance from Professor Sherwood and Dr. Reed, authors of the first edition, must then be considered as an excellent book in chemical engineering and a notable contribution to engineering in general.

What to do when attacked by a differential equation is covered in chapters 3 to 10. The over-all presentation on setting up and solving differential equations is an extraordinarily fine discussion of methods. Because the chemical engineer must more and more concern himself with the solution of all sorts of hideous differential equations, he will find the presentation in the book to be most helpful.

The approach to developing and solving miscellaneous equations in chemical engineering situations is again an important feature of the book. In Chapter 3 there is discussion on the formulation of the physical problem. It emphasizes the comforting word statement that input minus output is equal to accumulation. This statement is truly basic to the establishment of equations describing physical and chemical processes, and the chapter deserves study and understanding by both the neophyte and the old hand. Conservation of material and energy are considered along with the ideas of the steady and the nonsteady state.

In Chapters 4, 5, and 6 attention is given to the solution of ordinary differential equations by analytical and numerical techniques. Chapter 5 is of special interest because of a well-arranged presentation on the use of infinite series in the solution of certain types of differential equations. The table on page 177 wherein comparisons are given of Bessel-function notations used by different authors is most helpful. About the only criticism that can be given on the section on series solution of differential equations is that the coming years will see more need of familiarity with some of the less-used functions such as those designated as Legendre, hypergeometric, Laguerre, Hermite, Tschebyscheff, and Jacobi. It is possible, then, that more space should have been devoted to those functions, not only for formal discussion but for examples.

Formulation of partial differential equations is discussed in Chapter 6. Vector notation is introduced to show the short-hand writing of partial differential equations for three-dimensional coordinate systems. Coordinate transformations from cartesian to cylindrical and spherical are given along with a short presentation on the equations of motion for a perfect fluid.

Chapters 7, 8, 9, and 10 are concerned with one of the most sticky tasks to confront the chemical engineer—the solution of partial differential equations, and as stated by the authors on page 254 this "is essentially a guessing game." In Chapter 6, the more conventional analytical methods are discussed. Separation of variables, orthogonal functions, the Sturm-Liouville equation, expansion by single and double series of orthogonal functions, and Fourier series are considered.

The devotion of Chapter 8 to the Laplace transform is one of the highlights of the book. Certainly that transform is one of the more powerful tools in the solution of partial differential equations. Unfortunately there is too little facility in the use of the technique by chemical engineers, and Chapter 8 alone is worth the price of the book. The inclusion of Table 8-1, showing Laplace transforms, is appropriate. In order to handle the discussion on the Laplace transform in the best possible manner, an introduction to complex variables is included in the chapter. It is short and to the point, but the reader may wish to pursue the subject further with collateral reading.

Preparation for Chapter 10 on the numerical solution of partial differential equations is given in Chapter 9 where the calculus of finite differences is discussed and illustrated. The combination of the two chapters allows an attack on the problem of setting up partial differential equations as finite difference equations amenable to solution by hand or by automatic, high-speed computations.

The future in chemical engineering is certainly inexorably linked with advanced mathematics. The second edition of *Applied Mathematics in Chemical Engineering* truly gives a fine entrance to that future.

Auto Exhaust and Smog

Eye Irritation from Irradiated Auto Exhaust. (Report No. 18), 85 pp.; and *Reactions of Auto Exhaust in Sunlight* (Report No. 19, 71 p. $3 each; Air Pollution Foundation, Los Angeles, California.

Report No. 18 is on work done by Stanford Research Institute. Human subjects were exposed to exhaust-air mixtures in two principal series of tests. In the first, concentration plus residence time of exhaust mixtures in the radiation chamber were varied. In the second, the chamber residence time was held constant. Report No. 19 covers work at Midwest Research Institute. Glass reaction chambers of 2,200 cu.ft. were filled with unpolluted air, pollutants added, the mixtures exposed to natural sunlight, and the course of resulting reactions was followed over a period of 100 min. by chemical and physiological measurements.

Examination Questions for Preparation and Reference

Past Examinations for Professional Engineer. Published by John B. Constance, 625 Hudson Terrace, Cliffside Park, New Jersey, mimeographed, 75 p. $2.00 postpaid.

These examinations, fairly typical of those given by many states in the northeastern part of the country, were given by the New York State Board during 1946-56. Part III-B of the New York examination places more emphasis on chemical engineering calculations than is found in some states.

Professional Engineer's Examination Questions and Answers. William S. LaLonde, Jr., McGraw-Hill, New York (1956), $6.50.

Cloth-bound and arranged for ready reference, this book contains well-worked out solutions to examination questions. These advantages may justify the higher cost of the work to some engineers.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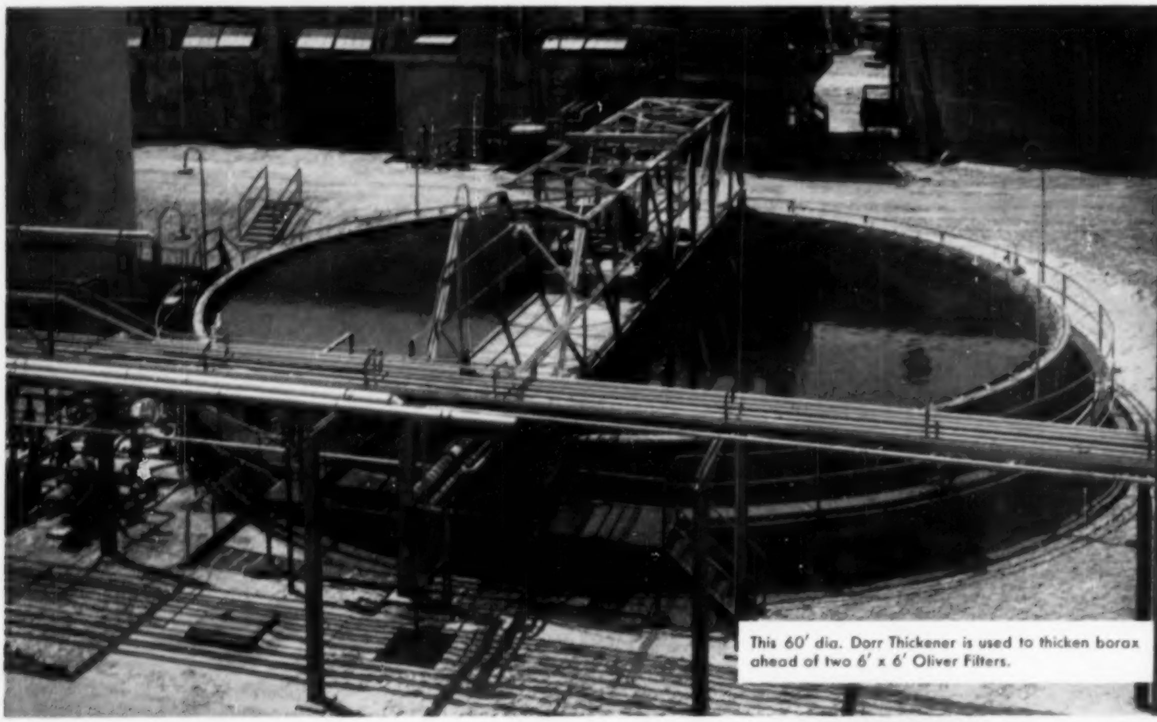

This 60' dia. Dorr Thickener is used to thicken borax ahead of two 6' x 6' Oliver Filters.

DORR-OLIVER TECHNIQUES

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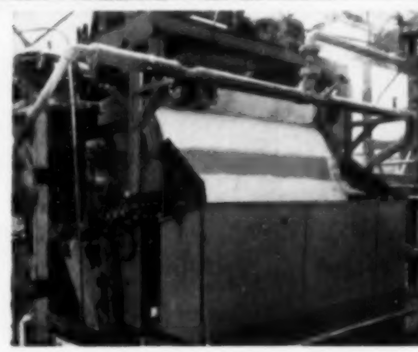

This 6' dia. by 8' fabricated stainless steel Oliver Salt Type Filter handles about 200 TPD of sodium bicarbonate. Note how clean the snap blow leaves the screen. A 2" thick cake is discharged at 28% moisture with the aid of press rolls.

Tonnage producers of potash, sodium carbonate, borax and sodium sulfate, American Potash & Chemical Corporation makes skillful use of Dorr-Oliver equipment and methods at their giant Trona, California plant. D-O Thickeners, Filters and Classifiers are used in virtually every wet processing step in the flowsheet. On the Filters alone, over forty different units are installed . . . Oliver Drums, Oliver Salt Type, Horizontals and Sweetlands.

For the Process Industries, Dorr-Oliver offers a complete and integrated service. Well-designed equipment, as installed at AP and CC, is an important part of this service. But if your processing needs involve laboratory and pilot plant testing, flowsheet preparation, economic analysis or complete plant design and construction, we can also be of help. For a complete picture of the scope of the Dorr-Oliver technical service write for a copy of Bulletin No. 7003. Dorr-Oliver Incorporated, Stamford, Conn.

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About our authors

James T. Sheehy, born and raised in Seattle, educated at the U. of Washington as a chemical engineer, has been connected with the industrial and economic development of the Pacific Northwest during his business career. Now, as executive vice-president of Rayonier, he has responsibility for all timber, manufacturing, research, sales, financial, and legal operations of the company and its subsidiaries in Canada, Paris, and Japan.

Roy F. Weston is chairman of the A.I.Ch.E. Pollution Control Engineering Committee. As partner in the consulting firm of Weston and Eckenfelder Associates, Roy spends full time on pollution control engineering, except when his more and more frequent speaking appearances keep him away.

Marcus Sittenfield received his chemical engineering training at the College of the City of New York.

Sheehy

Weston

Sittenfield

Lunche

Stein

Seymour

He formed his consulting engineering firm in 1947 after having been employed in industry in various capacities that gave him a broad background in chemical engineering. Among Mr. Sittenfield's several fields of present interest is the control of air pollution created by chemical and related operations.

Robert G. Lunche studied chemical engineering at Minnesota and Illinois Tech. He is at present acting assistant chief of the evaluation and planning staff of the Los Angeles County Air Pollution Control District. Mr. Lunche has for the past two years been assistant chairman to the Joint District, Federal and State Project for the Evaluation of Refinery Emissions. **Arnold Stein** is an intermediate engineer with the Los Angeles County Air Pollution Control District, presently in a technical advisory capacity. He formerly specialized in high temperature dust and fume con-

(*Continued on page 32*)

About our authors

(*Continued from page 30*)

trol. **Clifton J. Seymour,** a chemical engineer from Missouri, has recently been named to the directorship of the Riverside County (Calif.) Air Pollution Control District following ten years of experience as a petroleum technologist. **Ralph L. Weimer** is a chemical engineer on the evaluation and planning staff of the Los Angeles County Air Pollution Control District.

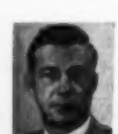
Richard J. Ruff is co-founder and president of the Catalytic Combustion Corp., Detroit, manufacturers of oxidizing catalysts and complete fume combustion and heat recovery systems. A Wisconsin chemical engineer, Dick was a professor of Industrial Engineering at Detroit Institute of Technology, also spent years in the high temperature process equipment field.

Lewis H. Rogers is senior chemist of the Air Pollution Foundation. Receiving his basic education in chemical engineering, he took his Ph.D. in chemistry. His experience has ranged from the faculty of the U. of Florida through the Chemical Warfare Service during World War II, and includes a period at Oak Ridge, where he was supervisor of the analytical research section in the gaseous diffusion plant. Finally, before joining the Foundation, he was supervisor of research in the analytical division of the National Dairy Research Labs in Oakdale, Long Island.

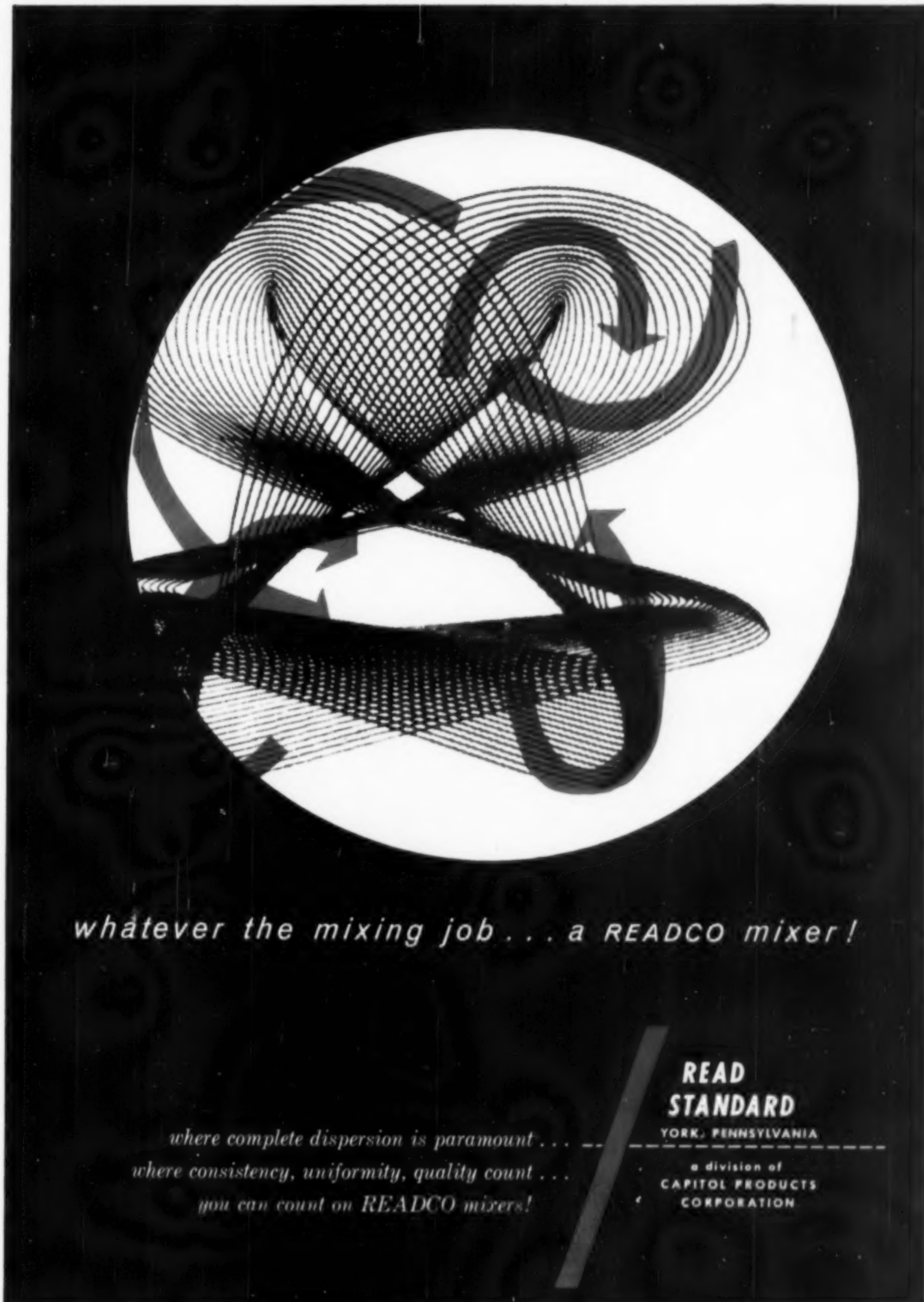
Kenneth E. Lunde is manager of the Industrial Air Research Section of the Chemistry Department at Stanford Research Institute, Menlo Park, Calif. In 1941 he joined the Henry J. Kaiser Co. at Permanente, Calif., as a process engineer. Later he was in charge of process design and instrumentation in the chemical division of Kaiser Aluminum and Chemical and with the Ralph M. Parsons Co. of Los Angeles as a mechanical engineer. Mr. Lunde is a specialist in technical and economical process evaluation and in the treatment of waste gases. **Charles E. Lapple** is a senior scientist in the Chemistry Department of S. R. I. Mr. Lapple, whose writings are well known to readers of *CEP*, started his industrial career with DuPont. From

(*Continued on page 34*)


Weimer


Ruff


Rogers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About our authors

(*Continued from page 32*)

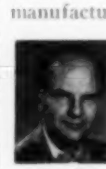
1941 to 1950 he was also a part-time lecturer in chemical engineering at Columbia U. and the U. of Delaware. In 1950 he joined the staff of Ohio State U. as an associate professor and in 1955 went to S. R. I.

Louis A. Pasteelnick and **William B. Leder** are chemical engineers engaged in process engineering with the Jersey City Division of Minnesota Mining and Manufacturing. Their interest in the use of statistical methods in planning experiments and interpreting plant data has led them to take graduate work in applied statistics at Rutgers U. Mr. Pasteelnick was employed by Merck & Co. before joining M. W. Kellogg Co. Mr. Leder worked for G. E. prior to joining Kellogg. Both became process engineers with 3M when the company bought the chemical manufacturing department of the Kellogg company.

Larry (W. L.) Faith is managing director of the Air Pollution Foundation, a private, non-profit research foundation in Los Angeles. Widely known to readers of *CEP* for his writings, his service as a director of the Institute, and for the prominent part he has taken in committee work and other affairs of the organization, Larry needs no further introduction in this issue, except to add one more credit to his long list: he was chairman of, and helped obtain papers for, one of the two sessions of A.I.Ch.E. papers which made up a major part of the recent Air Pollution Control Association meeting in St. Louis, from which came some of the pollution control articles appearing in this issue of *CEP*.

Harold Davidson, a chemical engineer trained at Columbia U., has been an assistant in the chemical engineering department there, with Kolker Chemical, Metal & Thermit, and is now doing engineering statistical work with Merck.

C. C. VanderWall, director of manufacturing at Ansul Chemical, Marinette, Wisconsin, has been working with other company executives for a number of years in the successful application of the principles of social science and operations research to manufacturing operations.



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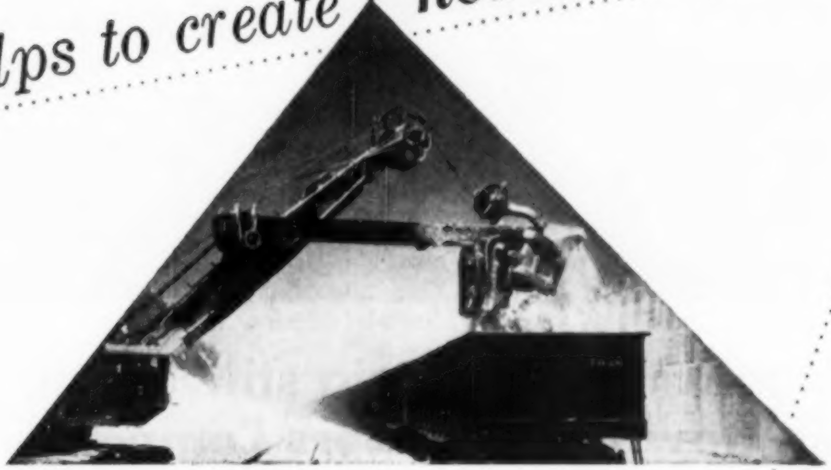
SULPHUR

helps to create headline products



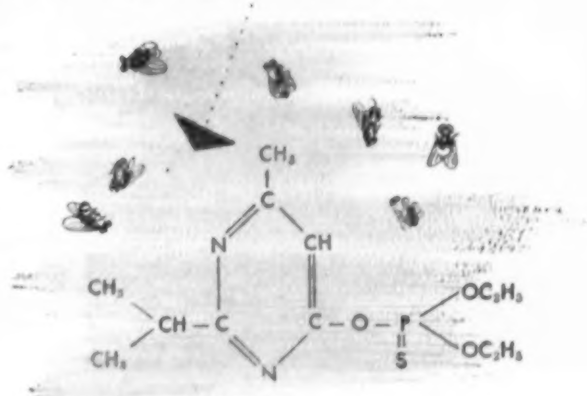
DIAZINON*

What a 'killer' this complex chemical is turning out to be! And quite impartial as to its victims: — houseflies, barnflies, fruitflies, aphids, mites, ants, beetles, chinch bugs, roaches, and many other pests that bother man and beast. It kills them dead!

As with the former chemicals which made such notable headway in man's fight to subdue these destructive pests, Sulphur is very much in the picture—here is one of the many variations of the benzene ring . . . the Diazinon Formula. That letter "S" tied in with the letter "P" discloses the all-important thiophosphate.

Sulphur, often called one of the Four Pillars of the Processing Industry, is benefiting mankind in many ways. None is more important than that of controlling crop-destroying pests.

****A product of the Geigy Chemical Corporation.***



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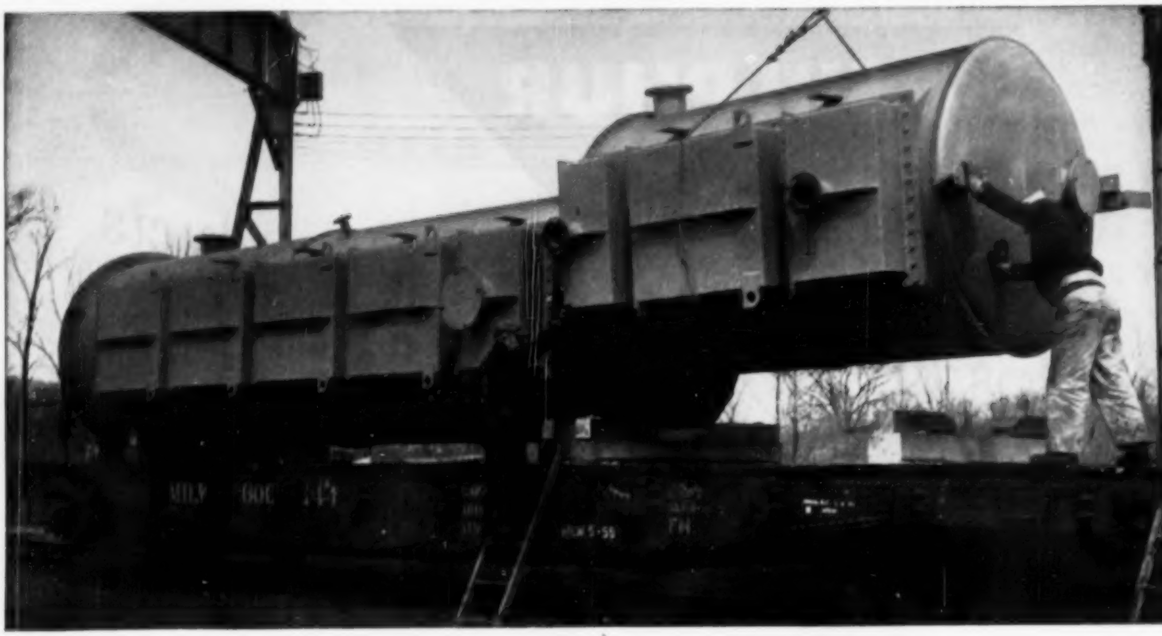

First fabricated ammonia still... built at Downingtown for Koppers Company, Inc.

When Koppers Company, Inc., Engineering and Construction Division designed this welded carbon steel plate ammonia still to replace its previous cast iron design, it naturally chose the fabricator with care. Close tolerances were required on positioning of risers, riser slots, bells, trays and weirs. We're proud of the part Downingtown had in this pioneering effort. This still is used for stripping the ammonia from ammonia liquor produced in a chemical recovery coke plant.

Interior of bottom section, showing position of rectangular bells fabricated from stainless steel, type 410. Thirteen trays, with bells.

THE UNIT WAS BUILT TO THE FOLLOWING SPECIFICATIONS:

Inside Diameter: 7′0″
Over-All Height: 37′10″
Design Data: 12 psi, 650° F.
Operating Data: 7 psi, 250° F.
Shop Test: 12 psi hydrostatic for 90 min.
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HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
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The highly research-conscious drug industry came up with few startling discoveries in new fields last year. The most recent have been the mental drugs, or tranquilizers, which were first used several years ago and have now become a $100 million business. Drug research is proceeding, however, on a more aggressive scale than ever. The major emphasis in most of the principal drug company laboratories, as well as in universities and medical schools, is now in the field of glandular drugs such as steroids and products from the thyroid. New steroid anaesthetics are on the market. Steroids are also used in the treatment of allergies such as asthma and hay fever.

Cortisone Family

Cortisone and its newer chemical relatives some years ago had a world shaking effect on the treatment of arthritis and rheumatism. But lately, scientists have begun to realize that drugs of this type are more numerous than heretofore suspected and that they may have much wider and (in some cases) more startling uses than is now known. The whole field of these compounds is still little understood. They are known to have major effects on body chemistry and metabolism, but the mechanics of how they act and interact is unknown territory. Concentrated research is going on to develop more potent materials of the cortisone type to treat arthritis.

A great deal of basic research is therefore being done and some interesting new compounds have been discovered. This, together with new uses which have been found for older compounds, makes it appear that the major discoveries over the next year or so may well come in this field. Virtually all of the leading drug houses are active in cortisone and related compounds, including Lederle, G. D. Searle, Schering, Merck, Pfizer, Warner Lambert, Parke Davis, and Upjohn.

Mental Disease

One of the important lines of approach is the search for and the study of new mental drugs. The tranquilizers have shown already that it is possible to treat some mental disease with drugs instead of just shock treatments and psychiatry. Psychiatrists who at first fought the idea are now coming around to accepting it.

What may lead to major future advances is the discovery that the brain itself and its tissues, in addition to the glands, is a marvellous chemical factory and apparently takes compounds made by some of the glands and converts them into other materials. In some cases it seems to send compounds to the glands to be stored. Research men are now studying these brain-created chemicals in an endeavor to throw more light on the function of body chemicals in brain processes and brain disorders. The work is still in early stages but it is easy to see that the ground work is being laid for some basic new knowledge. One firm has already come up with what it hopes will be an improved tranquilizer, chemically unlike any drug now on the market.

Another area attracting attention is that of the thyroid compounds, which some scientists call the most exciting new field in synthetic chemistry. At one time it was thought that thyroxin was the only product of the thyroid. Now it has been found that there is a whole spectrum of compounds apparently made by the thyroid. At least ten of these have been identified and work is being done to see if they can be produced synthetically, and to test out possible clinical uses.

Some of these products appear to have notable effects on blood cholesterol and so might have a use in treating arteriosclerosis. There may also be some connection between thyroxin and mental disease because it has been shown that schizophrenics are insensitive to thyroxin and apparently cannot use it. One of the new thyroid chemicals, tested on frogs, has been shown to be an extremely powerful growth stimulant.

One new glandular product, trade-named Releasin, is derived from hog ovaries and is sold to prevent premature birth of children. It also appears to ease normal childbirth but is still too costly for general use. Research in processing is bringing costs down. Like other drugs in this field, this product gives indications of other important uses. It appears to have rejuvenating effects on body tissues and blood vessels and has been shown to be effective in the treatment of an obscure skin disease.

Several firms have developed a new steroid compound used to treat menstrual disorders in women and under some conditions to correct sterility. The same material may also be used to prevent ovulation and thus is an oral contraceptive, although the makers are not recommending it for this use.

Geriatrics

Scientific work is uncovering an increasing amount of evidence that aging and chronic disease may be linked to a slowdown in the body's hormone factories, rather than to a speedup of body cell destruction. The hormones affected most by advancing age are those which help promote the building of protein and bone tissue in the body, some scientists believe. From this it is reasoned that older people might be treated with a sort of replacement therapy to supply hormones which are in insufficient supply because of disease.

CEP

opinion and comment

CHEMICAL ENGINEERING AROUND THE COUNTRY

"Chemical engineering around the country" is an interesting subject, considering some of the variations in conditions, opportunities, and achievements found in different regions. Take the Far West, and more specifically the processing of uranium-containing ores for the production of "yellow cake." This is the oxide form which is shipped to the A.E.C. for further refining to the metallic state. A number of commercial firms are now engaged in the production of yellow cake, some operating original A.E.C. facilities, others operating or building their own.

One of the complexities in the production of yellow cake has to do with the extreme variation in quality and content of raw material fed into the "mill," as such facilities are called. No classification is performed at the mines, at least in the ordinary sense. Miners are said to alter quality of their truckloads somewhat by adding some ore from richer veins when their radiation counters indicate a load may be a little "light" in quality. To the processors, however, each mine's output is kept separately until its quality is known. Then it is categorized and grouped in storage bins by different processing qualities. These batches require expensive shifts in processing techniques from run to run.

The mills vary considerably in their processing techniques, particularly when it comes to final separation of the uranium compounds or ions out of solution. Early operations adopted the then conventional regimen of selective precipitation. This, however, has many disadvantages, considering the leaner and leaner ores which the mills are receiving, compared to just a few years ago. Ion exchange came along and offered a means for economic removal of uranium when present in extremely dilute concentrations. But it has been learned by bitter experience that some ores, or batches, contain materials which poison the exchange resins, making them ineffective. The molybdenum ion is one—but only one—of the offenders.

Now solvent extraction is being adopted by the latest mills under construction. In one of these, a mixer-settler will be used; in another, a centrifugal extractor. Already, the problem of poisoning of the amine used in this operation (by the same ions that plague the exchange resins) is causing concern to the operating executives.

The rapid progress made—under the aegis of A.E.C.—by the commercial firms in the founding of a highly productive yellow cake industry is deserving of the highest credit all around. The serious problems and adjustments this industry faces in the near future are being widely discussed by the participants. There is a rapidly growing realization that the old metallurgical practice of wholesale operations must give way to one much more scientific, a result of better understanding of the really complex chemico-physical operations taking place in the large vats, etc.

Here is another challenging field for chemical engineering, one that can be approached most effectively if proper understanding of what chemical engineering can do might be communicated to the highest echelons of the yellow-cake producing industry, as well as A.E.C. Important also is whether or not there are enough chemical engineers willing to approach the problems of this frontier operation—not in campus-like, air-conditioned facilities, but living in a tough country, working with people who get results from difficult rock, but who do so with fine humor and spirit.

J.B.M.

This steam stripping dephenolizer at Barrett Division's Frankford Works, Philadelphia, is an example of preventing pollution before it occurs—by appropriate chemical engineering design.

Roy F. Weston | Weston & Eckenfelder Associates, Inc. Newtown Square, Pennsylvania

the role of the CHEMICAL ENGINEER in INDUSTRIAL POLLUTION CONTROL

Solution of the growing problems of industrial pollution control demands an intimate knowledge of, and association with, the source of industrial wastes. It requires also knowledge of process factors and unit operations; knowledge of the composition of wastes; familiarity with operations research techniques; and acquaintance with research and development organization and accomplishments.

A Challenge to the Chemical Engineer

Because of its position in industry, the chemical engineering profession has a unique opportunity to accomplish more good in industrial pollution control than any other professional group. The chemical engineer is intimately associated with process development: he designs manufacturing processes; he participates in the preparation of detailed engineering plans and specifications; he supervises processing operations, and he is commonly found in the ranks of management. In short, the chemical engineer has the most complete control of the source, quantity, mode of occurrence, characteristics, and disposal of industrial wastes. Even more important, his part in process development affords him the greatest challenge of all. He has the opportunity to develop processes with minimal amounts of waste. He should therefore be trained in the philosophy, the art, and the science of pollution control. His training should be sufficiently complete and fundamental so that pollution control is always in the back of his mind as he performs his normal duties.

Pressure Grows for Pollution Control

Unfortunately, it appears that very few chemical engineers get adequate training in this field. Educators should not be severely criticized for this, however, because they have put first things first. To date the sanitary engineer has done a reasonably good job of correcting pollution by treatment of wastes. Industrial pollution has been more of a nuisance than a serious health hazard because there has been plenty of air and water available for dilution. Since it is only in the past ten to fifteen years that industrial pollution has been of general public concern, there has been no strong driving force to require the training of chemical engineers in pollution control. The situation is now different: over 40 of the 48 states and the Federal Government have specific water pollution control legislation. A number of states have enacted or are considering enactment of legislation specific to air pollution control. Both major political parties are committed to pollution control because of the pressures applied by civic and conservation groups. These groups include, among others, nearly 20,000,000 hunters and fishermen.

Economic pressure will be applied by those competing for clean air and water resources. Those who have already spent \$7-8 billion to abate pollution will protect their competitive position by insisting that others provide pollution control.

The rapid rate of industrial expansion and population growth is placing an increasing load on the fixed, and in many cases limited, dilution and self-purification capacity of our natural resources. Therefore, the need for pollution control is increasing as time passes. By the time our current crop of chemical engineering graduates are managers, pollution control may well be a major problem for their industrial plants. Consequently, these engineers should be receiving training in the philosophy, art, and science of pollution control now.

Danger of Waste Emission

Pollution control law is based on the general philosophy that the discharge of any wastes that adversely affect the health, welfare, or comfort of the public, or is inimical or injurious to the environment, is against public policy and is a public nuisance. Pollution control can rarely be justified by conventional economic considerations. It is something that must be done to be a good citizen and neighbor. The pollution control require-

ments established by regulatory agencies are not the result of economic studies but are the result of investigation of the best available information pertaining to the effects of wastes on the population, the environment, and environmental uses.

The problem of economics belongs solely to the polluter. Competition and rising construction costs make it imperative that pollution be abated in the most economical manner. One of the most economical ways to abate pollution is by the use of "preventive measures" which include various in-plant practices.

POLLUTION PREVENTIVE MEASURES

- **Engineering design considerations**
  1) Installation of separate drainage systems
  2) Segregation and collection of specific wastes
  3) Use of surface condensers in place of barometric condensers
  4) Use of various water conservation measures and facilities
- **Process Design Modifications**
  1) Process selection
     a. Use of reaction chemicals or feed stocks producing minimum waste
     b. Continuous vs. batch processes
     c. Chemical regeneration
     d. Downgraded use of chemicals
     e. Elimination of air blowing and water washing
  2) Loss control
     a. Physical separators
     b. Change in design basis for chemical recovery facilities
     c. Modifying operating conditions
- **Recovery and utilization**
  1) Recovery for reuse in process
  2) Downgraded use of spent chemicals in other processes
  3) Use or sale of wastes as raw material for other processes.
- **Local Pre-Treatment or Disposal**
  1) Local separators and traps
  2) Evaporation and incineration of noxious liquid wastes
  3) Use of emulsion prevention chemicals
- **Operation Control**
  1) Automatic vs. manual process controls
  2) Emergency storage facilities
  3) Administrative control of waste discharge connections
  4) Monitoring sewer effluents
  5) Management follow-up on losses
- **Good Housekeeping**
  1) Conservation and clean-up programs
  2) Publicity and educational releases (booklets, signs, etc.)

The accompanying tabulation indicates a few of the things that can be done as preventive measures. The classification is arbitrary.

In each plant there are many places where relatively minor and low-cost modifications in process, equipment, or operation procedure can significantly reduce pollution. Such modifications or changes may not be well accepted by operating personnel and may in some cases restrict operations. The chemical engineer in charge of process operations can best educate the operators in the wisdom of preventive measures and can best evaluate the economies of the use of preventive measures versus waste treatment. Complete waste control to meet regulatory standards may not be possible by preventive measures alone, but such measures can greatly reduce the cost of installing and operating waste treatment facilities.

Management should establish policies requiring consideration of pollution control during the development, selection, and detailed design phases of new installations and the major modification of existing facilities. Study of waste control problems during the development and design stages will influence the selection of the process, the details of process design, and the detailed design and construction of engineering facilities. After the facilities have been made available to the operators, operation control procedures and good housekeeping techniques must be established and administered persistently to effect economical waste control. Management must establish the principles to be followed in the practice of pollution control. Only an informed management can intelligently direct pollution control efforts without fear or prejudice.

The chemical engineer alone cannot assure the most economical waste control. He must have the assistance of the chemist, the biologist, the meteorologist, the hydrologist, the sanitary engineer, and others. Nevertheless, his position in industry affords him an excellent opportunity to reduce duplication of effort and minimize research and development costs by encouraging cooperative effort of professional societies and trade associations. He has the challenge of exerting a needed strong, honest, fearless, and statesman-like leadership. Some may choose to become specialists in the field. Nevertheless, the major role of the profession will probably be that of achieving pollution control at minimum cost through the use of preventive measures. In the meantime, the young chemical engineer's usefulness in this role should be assured by his receiving, as a part of his regular training, as much information on the problems and techniques of industrial pollution control as will soon be required of him.

Marcus Sittenfield

Marcus Sittenfield & Associates, Philadelphia, Pennsylvania

Chemical engineering aspects of air pollution control have not been recognized fully until recent years. Such recognition was the result of the emphasis placed by designers of control apparatus on the elimination of smoke and particulate matter from gaseous effluent. This emphasis was aided further by the enactment of legislative standards aimed at regulation of the more obvious polluting effluents: namely, those from combustion processes. These standards set up maximum allowable smoke density and fly ash emissivities.

The public demand for regulation of other air pollutants was not present except in isolated areas, chiefly around copper, lead, and zinc smelters. In these areas, sulfur dioxide and arsenic fumes caused major damage to crops and livestock. Lawsuits and injunctions forced companies to investigate and install ways and means for the elimination of these polluting substances.

As the chemical and petroleum industries grew in size and number, people living in the neighborhood of such plants would register more frequent and louder complaints with the increasing incidence of obnoxious, nauseating, acrid fumes and gases discharged from these operations.

News reports of tragedies caused by smog and pollution sparked public and legislative interest into enacting more inclusive ordinances. Today's modern laws, besides containing restrictions as to the amount of particulate matter or smoke discharged into the air, also prohibit the emission of gases, mists, or fumes that may be toxic, obnoxious, or that are a nuisance.

Role of Chemical Engineer

This growing pressure to eliminate the discharge of all types of pollutants presents a tremendous challenge to the chemical engineer.

In this review, the highlights of the place chemical engineering holds in the field of air pollution control and measurement are discussed. The cost of equipment and of process operation is of prime concern to the chemical engineer who has the responsibility for the elimination not only of industrial air pollution, but also of that arising from the daily activity of all people.

CHEMICAL ENGINEERING ASPECTS OF AIR POLLUTION CONTROL

There are two groups in our modern civilization that contribute to contamination of the atmosphere: one is industry; the other is the public.

Industry is conscious of the necessity for minimizing or eliminating the venting of any chemical waste from its operations. It does an excellent job in recovering economically valuable gaseous wastes. However, there are areas in which more work must be done, chiefly those that may be termed "residual wastes" and that are not economical to recover. Manufacturers are finding it necessary to seek efficient means for eliminating the discharge of this type of pollutant in order either to reduce plant maintenance resulting from corrosion and wear of equipment or to establish good public relations with the community in which they work.

The problems associated with controlling the emission of pollutants by the public are complicated by the fact that usually the amounts discharged by an individual are small, discontinuous, and dilute. Further, there is no incentive to install control equipment.

The process design is the first place where air pollution control should be attacked. The engineer who is well acquainted with potential sources of atmospheric pollution should be brought in on the process design as soon as the laboratory turns the research project over to the pilot plant and design groups. In some instances, it may be profitable for this engineer to work along with the research team.

Controlling Pollution Sources

It would be purposeful here to review the more common sources of air pollution directly attributable to chemical reactions or chemical manufacturing operations. A look at industrial sources and a subsequent grasp of what chemical engineering design features are required to minimize pollution will clarify the problem.

Perhaps one of the more difficult types of pollution to control is that resulting from general ventilation of plant areas and equipment. Plant area pollution results from careless housekeeping; poor maintenance of motive equipment, chiefly stuffing boxes and seals on pumps and agitators; improper ventilation of atmospheric reaction vessels; and the venting of storage tanks.

In controlling pollution derived from *poor housekeeping* and *maintenance of equipment*, the means are quite obvious: namely, prevention.

In the design of *reaction vessels* consideration must be given to either or both of two factors—to be specific: (1) the case where a gas is evolved from a reaction, and (2) a case where no gas is formed, but the reactants have a sufficiently high vapor pressure that they volatilize readily.

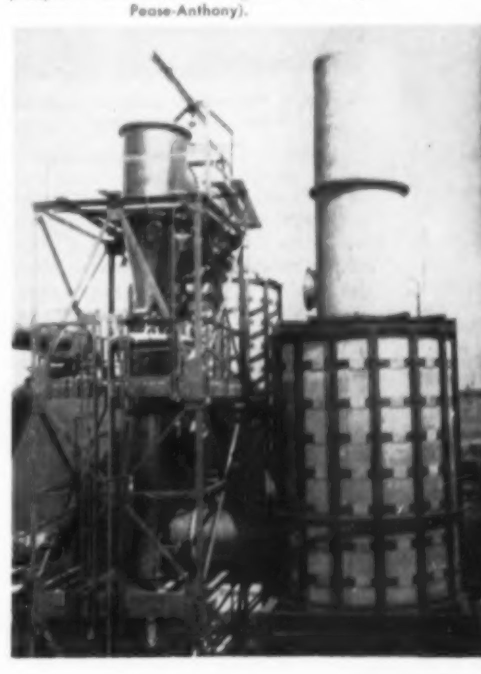
If tanks are operated at atmospheric pressure, the air moving equipment must be designed to accommodate the maximum rate of gas emission plus an amount of outside air sufficient to maintain a negative pressure up to 1 in. H_2O when the maximum amount of gas is being evolved. This will be equivalent to indraft velocities, under these conditions, across all vessel openings of between 100 to 200 ft./min. When reaction vessels are charged with dusty powders or liquids of high volatility, the amount of air required to prevent vapors or dusts seeping into the plant must be such that a minimum indraft velocity of 75 ft./min. is obtained across all openings. Where reactions occur at superatmospheric pressure, the relief valve and control system must be sized to accommodate the maximum rate of gas evolution. The vent lines from these vessels should be connected to appropriate scrubbing, absorption, or adsorption equipment that will remove any polluting material.

Another major source of organics in the atmosphere is *storage tanks*. The amount of solvent loss through storage tank "breathing" and the alternate filling and emptying of tanks can be appreciable. It has been reported that the oil industry loses between 6 and 12 million barrels of crude oil each year by evaporation.

Distillation units can be an important source of air contamination. The main point of discharge is the condenser. The efficiency of condensation will determine the amount of polluting material vented. If vapor pressures, terminal temperature of the cooled vapors, and column throughput are known, the concentration and total quantity of these substances can be calculated.

In the design of condensers, consideration must be given to the fact that small amounts of noncondensable gases, such as air, have a marked effect on coefficients of condensation.

Venturi scrubber, Haveg construction, handles phosphoric acid concentrator gases. (Courtesy Pease-Anthony).



In addition to the thermodynamic design of the condensing unit, a good mechanical design of the system to prevent mist formation and carry-over of mist or droplets with the noncondensable stream is a necessity. When a distillation unit is operated at atmospheric pressure, a well-designed vent condenser with the use of chilled water as a refrigerant would be invaluable in reducing the emission of the volatile overhead product. If the material boils over 125° C., a properly designed condenser may be sufficient to condense 99% or better of the overhead vapors. In some few cases where the overhead substance has a penetrating odor at small concentrations (measured in p.p.m.), it may be necessary to install scrubbers or adsorbers in the vent.

View of a disassembled polyester scrubbing tower. (Courtesy Haveg)

The air contamination problems associated with vacuum tower operation stem directly from the discharge of the vacuum pump or vacuum steam jet to the atmosphere. Air leakage into a vacuum system becomes important in determining the amount of air pollution that may result. As the air leakage increases, the dew point of the vapor becomes lower; consequently the temperature of the cooling liquid must be reduced correspondingly if the last traces of vapor are to be removed.

Another possible source of air pollution is the hot well vapors or the exhaust from the final stage steam jet. The hot well should be enclosed and vented through a condenser, and it would be desirable to condense the exhaust from the steam jet and pass the noncondensables through a scrubber or adsorber.

Up to this point, only vapor or gaseous pollutant sources from processing equipment have been discussed. In some portions of the chemical industry, mixing, grinding, and drying operations are performed in which solid particles may be carried by an air stream into the surrounding atmosphere. The project engineer must be on the lookout for these sources, as dusts, mists, and fumes can be highly irritating. A knowledge of the solubility, wettability, and particle size distribution is most important in selecting the optimum type of control apparatus. In some cases, the exhaust gases are at such an elevated temperature that normal filter materials will not stand up; hence gas cooling will be required.

Careful design of the cooling process is most important as it is undesirable to cool the gases to a point where condensation occurs. If this should occur, the moisture will cause plugging of the filter medium.

The classes of apparatus most often used for the solution of dust problems comprise filters, scrubbers, impingement and inertial separators, and electrostatic precipitators.

Control Processes

The next important phase of air pollution control is the process to be used for its control. Once the sources of pollution have been recognized and every effort has been made to prevent the escape of pollutants into the general atmosphere, then the engineer must seek and design equipment to remove these substances from the vent stream. These have been indicated as including *adsorption, extraction, absorption,* and *incineration.* In the design and the selection of the appropriate control method chemical engineering plays an important role.

ABSORPTION

One of the tools available to the chemical engineer in combating air pollution is that of *absorption.* Closely akin are scrubbing, and extraction. The basic data needed to design equipment in this group are mass transfer between the absorbing liquid and the absorbed vapor, diffusion in the gas and liquid phases, and area of contact between liquid and gas. Contact between liquid and gas may be accomplished by the use of impingement sprays, jet scrubbers, bubble plate, sieve plate, and packed towers.

Because it is important in the design of air pollution control equipment to minimize pressure drop, the equipment used most often fall into the impingement spray, jet scrubber, and packed tower group.

To design these units, such fundamental information as equilibrium relations, diffusivity constants, and the function correlating mass transfer rates with height of transfer units must be available. In many instances, these functions may be calculated from existing data or from experimentally determined correlations.

One of the main problems facing the designer is that the concentration of gases usually found in air pollution work is quite small, often under 10 mole %. Consequently, in order to minimize equipment size, the absorbent having the greatest solubility of the gas should be used. In some instances, however, it is cheaper to use water as the absorbent, even though solubility of the gas is low, since the resulting effluent may be thrown away. The engineer is cautioned that by so doing, he may be solving one type of pollution problem by creating another one: namely, stream pollution.

The chemical reactivity of the pollutant is most important. In one case, an organic chemical possessing an unpleasant odor was thought to be acidic in nature. Dilute caustic soda was selected as the absorbent without effect. After much investigation, it was found that the chemical gave a basic reaction. The problem was solved by using a waste sulfuric acid stream to absorb the gas and eliminate the discharge of odor. A caustic soda tower followed the acid scrubber to eliminate the venting of any acid mist.

EXTRACTION

When solvents are used, means must be provided for stripping the absorbed gases from them; otherwise the cost of operations becomes excessive. A typical example of this is the recovery of hydrogen sulfide with diethanolamine solutions as the solvent.

In general, there is a sufficient amount of equilibrium data available for the solubility of many of the common gases in water. A number of absorption studies have been made for other systems where the gas streams are pure or fairly concentrated. But, there has been little quantitative data published for the absorption of gases and vapors from dilute streams. More work along this line should be undertaken. These data will prove helpful to the engineer by permitting a more economical design of equipment. In addition, there can be set up in the various codes more meaningful concentration limits that could be obtained without excessive capital and operating costs.

The diffusivity of gases through gas and liquid films often may be calculated from known information on other systems or by the use of accepted correlations such as Gilliland's empirical equation.

Scrubbers, particularly the spray or jet type, are used frequently for fume and mist control. The engineering design principles for this operation are based on impingement, coalescence of micron-sized particles, direct condensation or wetting of the mist or fume particles by the liquid. Direct condensation methods are effective when high boiling vapors of fatty acids, tar acids, etc., must be removed from vent streams.

Little published design data, suitable for calculating the efficiency of scrubbers of the spray or jet type, are available to the engineer. Such facts as the relationship between spray volume and transfer units, the effect of surface tension, as it relates to the wettability of fumes and mass transfer rates are still far from being in a state where a predictable design can be made.

A knowledge of particle wettability is extremely important in determining how effectively a unit will remove a fume or foglike mist from a gas stream. At present, high energy impingement scrubbers or electrostatic precipitators are used for this operation. Power costs and large scrubbing liquid requirements present problems that in some instances make control of air pollutants by these means unattractive.

ADSORPTION

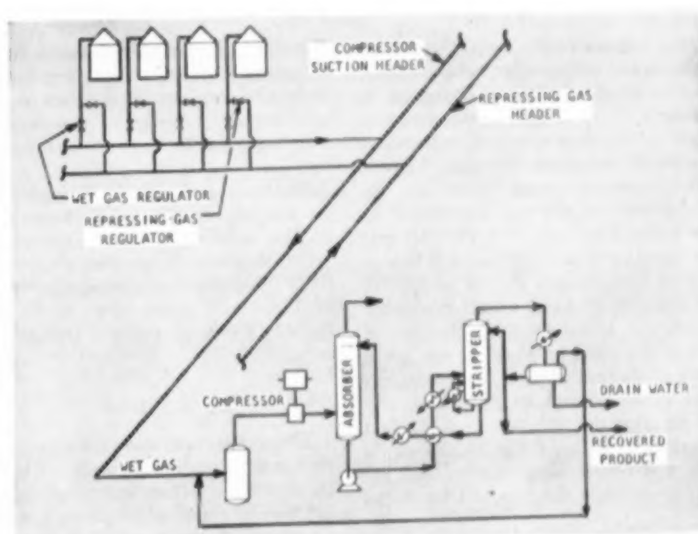
When the concentration of pollutant in the vent gases approaches a value of 2 vol. % or less, a most attractive means for removing almost 100% of the contaminant is by *adsorption*. Even when concentrations are measured in parts per million, properly designed adsorption apparatus will remove substantially all the contaminant. One of the major uses of adsorption is the recovery of solvent vapors by the use of such substances as activated charcoal, activated alumina, or silica gel.

Basically, adsorption processes work by causing condensation of the vapors at a temperature much higher than that indicated by their concentration. In this operation, latent heat is released. Since the efficiency of adsorption decreases with increasing temperature, it becomes important for the designer to install methods for removal of the latent heat.

Reactivation or desorption of the adsorbent is usually accomplished by heating the adsorbent and subsequently condensing the desorbed vapors in a surface condenser. The recovered condensate, in most instances, must be purified further, usually by distillation.

The affinity of an adsorbent is not the same for all substances. As a result, the vapor having the greater intensity of adsorption will displace other vapors of lesser intensity that may have been adsorbed previously. This phenomenon is the basis of hypersorption separation processes used in the petroleum industry.

As the design of all air pollution control equipment requires that low pressure drops be engineered into the unit, the gas velocity through a deep bed of granular adsorbent is kept low,



Schematic diagram of a vapor recovery system for a tank farm.

of the order of 20 to 120 ft./min. As an alternate to deep beds, higher gas velocities may be employed if a parallel flow system with shallow beds is designed.

The rate of adsorption, or its reciprocal the contact time, is a function not too well known to engineers. Up to the present, there are few correlations that will permit the calculation of this factor based on such physical characteristics as pore size, pore area, activity as related to molecular structure, etc. As a result of the dearth of this type of design information, each new problem must be submitted to the laboratory for tests.

As the requirements for air pollution control become more stringent, the use of adsorption processes for the removal of low concentrations of air contaminants may increase, chiefly because

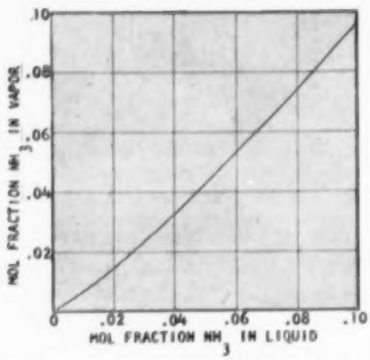
of their high efficiency of recovery and simplicity of operation.

INCINERATION

Another method for disposing of organic materials is by combustion. Nearly pure combustible streams, such as occur in petroleum refining operations, may be burned in a flare or used as a fuel. As the concentration decreases, a point is reached where the vent gases are too dilute to burn. In this case, an incinerator type of furnace must be designed. In some instances, the vented gases are used as secondary air in boilers and similar combustion equipment.

The main requirement in the successful combustion of air contaminants is to heat the flammable compound above the temperature of combustion. In most instances, the gases must be heated to a uniform temperature in the range of 1,200 to 1,400° F.

Passing dilute gases through the zone of combustion, as in the case where they are used as secondary air, will not necessarily insure that all molecules have reached the combustion temperature and consequently have been destroyed. The proper design of combustion chambers to provide both radiation surface and sufficient resi-



Equilibrium data for system NH_3-H_2O at 68° F.

dence time in contact with the radiant surface will increase the probability of complete oxidation.

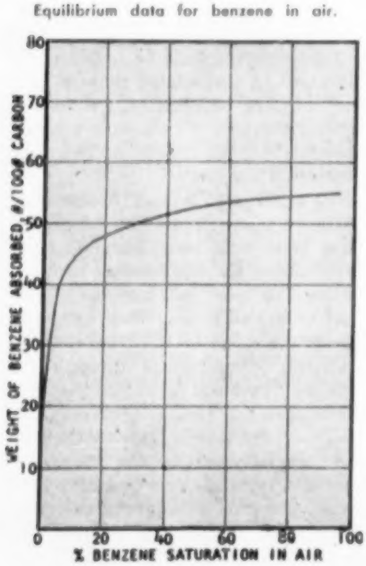
Catalysis

One answer to the requirements of high flame temperature and uniform heating of the flammable molecules is catalysis. Use of catalysts for reducing the activation temperature of chemical reactions is well known. Combustion processes are just as susceptible to catalytic activation as are other reactions. As an example, platinum catalysts will cause combustion at temperatures as low as 500° F.

In order to have a self-sustaining flame, the minimum concentration of gas in air must be equal to the lower limit of flammability. This concentration varies from 1 to 10 vol. %, depending on the substance. A distinct advantage to catalytic oxidation is that a self-sustaining reaction will result even when the combustible material concentration is down to one quarter of the lower limit. When concentrations fall below this point, it is not difficult to provide sufficient heat to raise the gas temperature to the 500 to 550° F. range required for operation of these catalytic units. Furthermore, it is reasonable to assume, that since catalytic reactions are dependent on molecular adsorption on a surface, if the contact time is sufficiently long all the flammable molecules will be oxidized.

A disadvantage to the platinum-type catalyst is its susceptibility to poisoning by contact with heavy metals (lead, zinc, arsenic), the halogens, and silicones. The selection and invention of stable oxidation catalysts that are immune to poisoning is a challenging problem.

Equilibrium data for benzene in air.



Other Problems

Among other problems faced by the designers of catalytic combustion units are stability of the carrier, increasing the activity of the catalyst, and lowering its activation temperature.

Most air pollution is derived from combustion processes, whether it be on the large scale of a public utility generating station or that discharged from the individual automobile, truck, or bus. And aside from smoke and fly ash, the largest single pollutant is sulfur dioxide.

REMOVING SULFUR DIOXIDE

There are two ways to attack the problem of sulfur dioxide: (1) to eliminate the sulfur in the fuel by extraction or chemical reaction, and (2) to remove the sulfur dioxide from the combustion gases by scrubbing.

In the case of solid fuels, it is almost impossible to remove sulfur and similar potential air pollutants prior to use. Hence, the only effective means of control is to scrub the flue gases. A good deal of work has been done in this country, by the T.V.A. and the U. S. Bureau of Mines, as well as in England, to devise economical systems for stripping the sulfur dioxide from flue gases. These methods have included, in the main, scrubbing with sodium and ammonium sulfite solutions forming the bisulfite and subsequent stripping by heat. Sulfuric acid may be made by oxidation with ozone or by the normal catalytic processes. Sulfur dioxide can be recovered economically as sulfuric acid from gas concentrations as low as 5%. Below that, the large volumes of gases that must be handled make the usual recovery processes economically unattractive.

The problem is somewhat simpler when liquid fuels are used. The petroleum industry is installing new methods, such as hydrodesulfurization for removing mercaptan sulfur from fuel oil and residual fractions. The sulfur is recovered as hydrogen sulfide which is then converted into sulfur.

LIQUID FUEL AND COMBUSTION ENGINE

Burning of liquid fuels in internal combustion engines poses another problem resulting from the incomplete oxidation of the hydrocarbons. Part of this may be solved by redesign of the engines themselves, improvement of carburetion, and changes in method of fuel injection. Another method that is being promoted is the use of catalytic combustion units. The chemical engineering problems met in the development of these units are substantially the same as those enumerated in the discussion of catalytic incineration. The problems of mechanical stability of the catalyst and susceptibility to lead poisoning are great and must be solved so that the over-all cost will be small and maintenance will not be noticed by the average automobile owner.

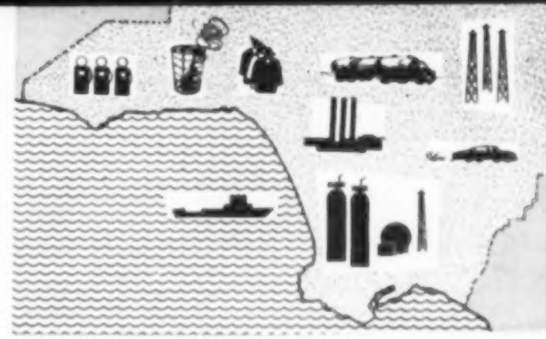
Instrumentation

There is one other point not yet referred to here in which chemical engineering functions: namely, instrumentation. Without proper instrumentation, the accurate measurement and control of pollutants is not possible. Various methods for recording gas concentrations continuously include mass spectroscopy, adsorption, conductance, infrared spectrophotometry, and chemical reactions.

In many instances, the method used for instrument analysis results in the formation or measurement of an electric current. For example, the Titrilog type measures an oxidation-reduction potential. It is used for such gases as sulfur dioxide, hydrogen sulfide, mercaptans, etc. A conductivity cell instrument may be used for any ionizable water soluble gas. Hot wire resistance is used to measure flammable gases. In all these units means must be used to remove all interfering gases. These methods may be chemical or physical. The analytical methods for measurement of polluting gases are in their infancy and offer a great opportunity for future development.

Presented at fiftieth anniversary meeting, Air Pollution Control Association, St. Louis, Missouri.

Organic-solvent usage in Los Angeles County approaching 600 tons daily has been revealed in the course of several surveys made by the Air Pollution Control District. It is estimated that only about 400 of the 600 tons are vaporized into the Los Angeles atmosphere. Information acquired through these surveys is detailed in the accompanying article in which the authors state that control may be achieved by adaptation of disposal equipment, reformulation of solvent-containing products so as to eliminate the solvents, and development of new techniques in surface-coating operations.



DISTRIBUTION SURVEY OF PRODUCTS EMITTING ORGANIC VAPORS IN LOS ANGELES COUNTY

R. G. Lunche, A. Stein, C. J. Seymour, and R. L. Weimer | Air Pollution Control District,* County of Los Angeles, California

The interest by the Los Angeles County Air Pollution Control District in organic solvent emissions to the atmosphere originated in 1949. At that time it was suggested that hydrocarbons were, in some way, participating in reactions leading to the formation of smog. These reactions consisted of the oxidation of organic material in the presence of sunlight in an oxidizing atmosphere (*6, 3*).

Considerable experimentation was undertaken in many laboratories to test the theory. Foremost among these were the experiments of A. J. Haagen-Smit, of the California Institute of Technology, and A.P.C.D. workers, who utilized the postulated reactions to prepare synthetic smog mixtures. The similarity between these synthetic smog mixtures and natural smog was demonstrated through their ability to produce eye irritation, damage to vegetation, rubber cracking, natural smog odor, and ozone (*1, 4*).

Since pure hydrocarbons or mixtures of hydrocarbons similar to those found in gasoline were used in these experiments, analogous reasoning indicated that organic solvents, which are hydrocarbons and hydrocarbon derivatives, would also be oxidized, such oxidation resulting in compounds with smog potential. Evidence confirming this has been published independently by A. J. Haagen-Smit and by A.P.C.D. workers, and the Franklin Institute Laboratories for Research and Development (*5, 2, 7*). Some of the organic compounds checked, other than pure hydrocarbons, were alcohols, aldehydes, ketones, acids, mercaptans, chlorinated hydrocarbons, and organic nitrogen compounds.

To assess the contribution of these and other organic solvents to the overall air pollution problem, the A.P.C.D. programmed a series of surveys to yield:

1. sources of supply for organic solvents
2. variety and volume of organic solvents marketed
3. consumers of organic solvents
4. sources of emissions of organic solvents
5. variety and volume of organic solvents emitted

Several of these surveys have already been conducted by mailing questionnaires, by making inspections of specific installations, and by conferring with representatives of industry. Company lists for the surveys were developed from District files, classified sections of telephone books, Chamber of Commerce listings, trade association membership rosters, and other governmental agency licensing and inspection records.

The initial survey which covered the organic solvent suppliers (manufacturers, distributors, jobbers, and brokers) identified the purchasers of solvents in Los Angeles County. From this, information was provided for "keying in" other surveys to the program and pinpointing the sources of solvent emissions. Additional surveys have been of:

1. dry cleaners
2. rotogravure plants
3. paint, varnish, enamel and lacquer manufacturers and distributors
4. Surface coatings users including:
   a. automobile assembly plants
   b. aircraft companies
   c. can and container manufacturers
   d. furniture manufacturers
   e. appliance manufacturers

In order that all information acquired through the surveys could be evaluated on a uniform basis, a definition of solvent was adopted. Classically, an organic solvent is an organic compound or mixture, usually liquid, which is capable of dissolving other solid, liquid, or gaseous substances. The definition adopted by the District required that for a substance to be considered an organic solvent, it had to be:

1. an organic liquid, capable of being evaporated or vaporized into the atmosphere at the conditions of its usage and storage, and
2. a substance used to dissolve, dilute, or disperse another substance (or substances) without itself being chemically changed.

Some idea of the diverse uses to which organic solvents are put can be observed in Table 1. It is evident that characterizing an organic chemical as a solvent in one instance does not guarantee that it can be considered always a solvent. To illustrate, xylene, when used as a paint thinner would be thought of as a solvent, but could not be so construed when used as a chemical intermediate for the manufacture of another product. This factor made knowledge of the ultimate uses of each organic chemical necessary in order to prepare solvent loss estimates.

Tabulation of survey data with respect to the variety and volume of solvents was facilitated by consolidating the more than 200 individual solvent and solvent mixtures marketed into eight classes. This classification is shown in Table 2. The general chemical formulae and examples of solvents for each class are also given.

The principal routes by which solvent vapors enter the atmosphere are natural evaporation or forced vaporization. Some operations or situations in which natural evaporation occurs are:

1. solvent storage vented to the atmosphere

* Mr. Lunche serves as senior air pollution engineer; A. Stein as intermediate air pollution engineer, and Messrs. Seymour and Weimer are air pollution engineers. All authors are on the Evaluation and Planning Staff.

2. manufacture of surface coatings in equipment vented to the atmosphere
3. dry cleaning
4. atmospheric drying of surface coatings

Vaporization is used to rid a product of solvent in

1. baking and forced drying of surface coatings
2. forced drying of printing inks during rotogravure operations
3. recrystallizing and purifying pharmaceuticals.

Survey by Mail

PRODUCTION AND SALES OF ORGANIC SOLVENTS

This survey was conducted during the third quarter of 1956 and, for convenience, requested the information to be averaged over the year 1955. Statistically, the survey showed sales to the different categories amounting

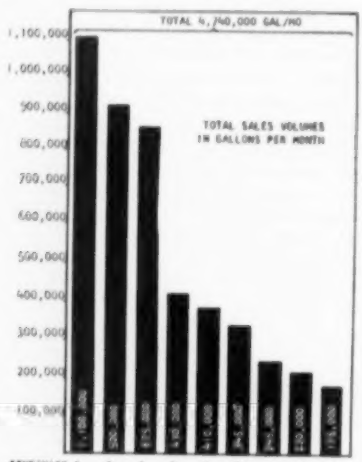


Fig. 1. Sales volumes of largest organic solvent suppliers in Los Angeles County, 1955-56. On request, company names are withheld to avoid disclosing competitive positions. (List includes all companies selling 100,000 gal./mo. or more in Los Angeles County.)

to 356 tons/day of aliphatic and aromatic hydrocarbons, 65 tons/day of halogenated hydrocarbons, and 171 tons/day of all other solvents for a total of 592 tons/day.

In all, seventy-six companies were contacted, covering, it is believed, all producers and distributors, including importers, making sales in Los Angeles County. All seventy-six companies responded with essentially complete information to the questionnaire form which was designed to solicit the following information for each organic solvent reported:

1. Trade name
2. Chemical name
3. Boiling range
4. Flash point
5. Vapor pressure
6. Density
7. Production rate, averaged for 1955
8. Sales volume to local buyers, averaged for 1955
9. Per cent of sales volume to individual buyer

Tabulation of data received reveals many interesting facts about solvent usage in Los Angeles County. The identities of the important solvents, solvent suppliers, and solvent purchasers, from the view of volumes sold, are all derived from this one survey. Table 3, Figure 1, Table 4, and Table 5 summarize these facts.*

Table 3 lists the most important solvents in order of sales volumes giving approximate sales volume only for the first, fifth, eighth, ninth, and eleventh ranking solvents. This method, although not definitive, does bracket the sales volume ranges for the other listed solvents.

In Figure 1 a comparison of volume of organic solvent sold by the principal suppliers is given, and in Table 4, an analysis of solvent usage is made. Figure 1 reveals that nine companies are responsible for sales of about 4,740,000 gal./mo. or 95% of the total solvent sales. All companies with sales above 100,000 gal./mo. of solvents were included in Figure 1. Table 4 shows that of the almost 600 tons of solvent sold daily in Los Angeles County (see Figure 4), the paint, varnish, enamel, and lacquer manufacturers purchase the lion's share in all organic solvent classes except that of halogenated hydrocarbons. In that class, the largest single share goes to degreasers. This is illustrated differently in Table 5, which ranks the categories by their percentage of total solvents marketed.

Tables 4 and 5 record purchases of raw solvents only and do not include solvents which are associated or contained in other products purchased such as paints, enamels, and adhesives. This note of caution is inserted so as to forestall the equating of purchases by various consumers with their solvent emissions, since in many cases they are not identical. This becomes clear when the losses of solvent from paint, varnish, enamel, and lacquer manufacturing are disclosed to approximate only 1 to 3% of the solvents purchased by them. The remaining 97 to 99% is lost at the point of use of such surface coatings and thus should be attributed to the automobile assemblers, aircraft companies, and the public. In such adjustments, it is important also to recognize that a significant percentage of products containing solvents may be exported from the local area so that evaporation of those solvents would occur elsewhere.

PRODUCTION AND SALE OF PAINTS, VARNISHES, ENAMELS, LACQUERS, AND OTHER SURFACE COATINGS

This survey was conducted during the latter half of 1956 and requested volumes as averaged for 1955. Production of all surface coatings was found to be about 2,700,000 gal./mo. requiring an organic solvent usage of about 1,300,000 gal./mo. About 40% of the surface coating production was exported out of Los Angeles County.

A total of 231 survey letters were sent to companies who classified themselves as manufacturers of one or more surface coatings, including those with a production as low as 200 gal./mo. Replies from these companies show that of the 231 contacted, 113 are actively engaged in manufacturing in Los Angeles County and the balance of 118 are either a warehousing operation, a sales office, or are out of business.

Previous information from a trade association that 90% of the total surface coating production could be credited to 10% of the companies was not substantiated by this survey. It was necessary to sum the production from approximately fifty of the largest plants in order to account for 90% of the total production. From this, the inference can be made that more than fifty of the manufacturing plants would have to be equipped with air pollution controls in order to realize any reduction in solvent emissions even approaching 90%. This is predicted on the assumption that surface coatings production and solvent usage are linearly related.

The questionnaire forms for this survey were mailed to each company with a request for the following information on the basis of average 1955 figures:

1. production, in gallons per month, individually for paints, varnishes, enamels, lacquers, and others.
2. production sold in Los Angeles County, in per cent, individually for paints, varnishes, enamels, lacquers, and others.
3. production sold as water-based types, in per cent, individually for paints, varnishes, enamels, lacquers, and others.
4. production sold for industrial spraying, in per cent, individually for paints, varnishes, enamels, lacquers, and others.
5. production sold for industrial dip and flow, in per cent, individually for paints, varnishes, enamels, lacquers, and others.

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* In deference to the requests of several of the companies surveyed who supplied confidential data, precautions have been taken to avoid issuing competitive sales statistics.

6. name, volume, and estimated manufacturing loss individually of all organic solvents used in production of paints, varnishes, enamels, lacquers, and others, respectively.

Totals of production and sales volume of surface coatings manufactured in Los Angeles County during 1955 are given in Table 6.

The volumes summarized in Table 6 lead to the following conclusions:

1. About 60% of the surface coatings produced in Los Angeles County are sold there and the remaining 40% are shipped out of the county.
2. About 20% of sales are destined for use in an industrial spraying operation.
3. About 4% of sales are destined for use in industrial dip-and-flow operations.
4. About 20% of total sales are made up of water-based paints.

About 1,308,000 gal. of organic solvents was purchased for the manufacture of 2,684,000 gal./mo. of surface coatings shown in Table 6. As some of the companies reporting did not maintain itemized records of the amount of solvents used in each product, only total volumes of each class of solvent are shown. These volumes are presented in Figure 2.

If the assumption of a linear relationship between surface coating production and organic solvent usage is correct, then 60% of the 1,308,000 gal. of organic solvents used in the manufacture are present in the surface coatings sold in Los Angeles County. This would amount to about 784,000 gal. of solvent a month which possibly could be released into the atmosphere from surface coating usage.

Solvent losses during the manufacture of surface coatings arise from evaporation from open processing equipment, evaporation during actual processing such as milling, and evaporation from equipment cleaning operations. According to available knowledge, no control of solvent emissions is practiced except for varnish cooking where fumes (which are not principally solvents) from the varnish kettles are incinerated.

The over-all estimated loss of solvent in the manufacturing processes is 1.2% by volume, equal to a daily loss of 516 gal. or 1.7 tons, with the use of a weighted average density of 6.7 lb./gal.

Survey by Meeting

ROTOGRAVURE PRINTING OPERATIONS

Seven rotogravure printing plants are now in operation in Los Angeles County with an eighth plant being installed. The survey was conducted in the latter part of 1956, through a series of meetings with representatives of the rotogravure industry and by inspections of their operations. Two of the larger printing ink manufacturers also were visited to obtain more detailed information about the solvents used in rotogravuring inks.

In rotogravure plants, organic solvents are used generally for two purposes: (1) to adjust the viscosities of the printing inks to the levels desired, and (2) to clean equipment.

Solvent emissions occur as a result of evaporation from storage, "fountains," "reservoirs," and equipment cleaning, and vaporization in the dryers. Some statistics on ink and solvent usage are totaled for the seven companies in Figure 3. From the data submitted it appears that about 25% of the organic solvents used in rotogravuring are associated with the purchased inks. The solvents used consist of 79% of aliphatic and aromatic hydrocarbons and 21% alcohols, ethers, and esters.

It is reasonable to assume that all the solvent used in rotogravure operations will be released into the atmosphere at the plant site, since the printed stock is dried immediately. No control of solvent emissions, other than some covering of solvent-containing equipment, is practiced.

To maintain consistency with other loss figures which are averaged over a 30-day month, the organic solvent emissions from rotogravure plants are computed as 7.3 tons per day. About 90 per cent of this amount is contributed by three of the seven plants.

ORGANIC SOLVENTS USED FOR DRY CLEANING

Surveys have been made to ascertain the volume of organic solvents used in dry cleaning operations. Questionnaire forms were mailed to groups of dry cleaning operators, selected at random. Of the 800 plus dry cleaning plants in the County, more than 300 have been surveyed.

Each plant was requested to supply the following information concerning its operations:

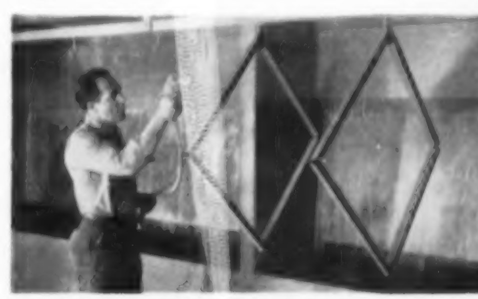
1. Average monthly volume and type of organic solvent purchased
2. Solvent-reclaiming equipment
3. Disposal of spent solvent
4. Operating schedule for dry cleaning equipment
5. Weight of clothes cleaned per month

Statistically, 60 per cent of the dry cleaning plants use chlorinated hydrocarbons and are known as synthetic

Milling of premixed paint paste for better dispersion is source of solvent vapor emission.

Rotogravure printing presses, showing dryers, steam lines to dryers, and exhaust systems.

Clothes being loaded into combination tumbler, extractor, and dryer of dry cleaning equipment designed for synthetic solvent usage.



Paint spraying operation showing spray cone and water curtain for capture of solid paint particles.

► Height of solvent vapor in this vapor degreaser is controlled by water-cooled jacket near top of degreaser.

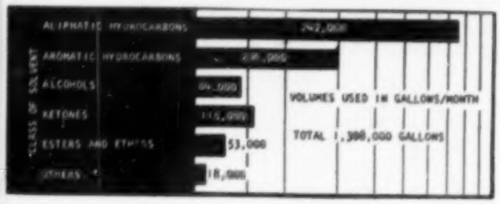
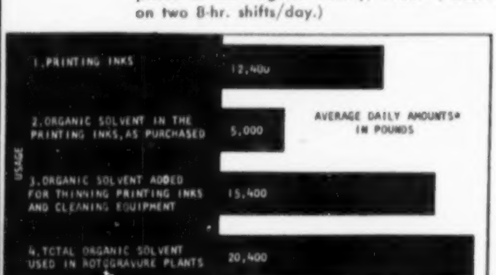


Fig. 2. Volumes of organic solvents used monthly for surface coating production in Los Angeles County, 1955.

plants, while the remaining 40 per cent use petroleum solvents and are referred to as petroleum plants. Nearly all of the "synthetic" plants have solvent-vapor condensation systems integral with the dry cleaning unit, while as a general rule petroleum plants do not have vapor collection. All the dry cleaning plants possess filtering systems and some operate "muck" (sludge accumulating from the dry cleaning) reclaiming equipment as well. Some of the larger petroleum plants also operate their own solvent reclaiming equipment.

The petroleum solvents used are aliphatic hydrocarbons, sometimes referred to as petroleum naphtha, and

Fig. 3. Ink and solvent usage in rotogravure plants in Los Angeles County, 1956. (*Based on two 8-hr. shifts/day.)



are either Stoddard Solvent, which is used in more than half the petroleum solvent plants or 140° F. safety solvent. The chlorinated solvents used are perchloroethylene (almost exclusively), trichloroethylene, and carbon tetrachloride (to a limited extent).

The smaller dry cleaning establishments, located usually in or near residential shopping areas, use synthetic solvents while the larger operators, usually located in industrial or commercial areas, use petroleum solvents. Wide variations have been found to exist in the relationship between weight of materials dry cleaned and volume of solvent used, especially amongst the smaller operators. It is quite possible that quantities of solvents in excess of that required are being used and wasted daily into the atmosphere.

Table 2.—Classification of Organic Solvents

Class name	General formula	Examples
1. Aliphatic hydrcarbons	R — H	Hexane, Stoddard Solvent, naphtha, mineral spirits
2. Aromatic hydrocarbons	Φ — H	Benzene, toluene, xylene
3. Halogenated hydrocarbons	R — X, Φ — X	Ethylene dichloride, trichloroethylene, perchloroethylene
4. Ketones	R — C(=O) — R'	Methyl ethyl ketone, acetone, methyl iso-butyl ketone
5. Alcohols (and glycols)	R — OH	Methanol, iso-propanol, sec-butanol
6. Ethers	R — O — R'	Ethyl ether
7. Esters	R — C(=O) — O — R'	Ethyl acetate, butyl acetate
8. Miscellaneous Aldehydes, terpenes, sulfur compounds, nitrogen compounds, mixtures	.....	Turpentine, carbon disulfide, nitromethane

R or R'—Any straight or branched chain hydrocarbon radical.
Φ—Any benzene ring-type hydrocarbon radical.
O—Oxygen atom X—Halogen atom
C—Carbon atom H—Hydrogen atom

Approximate monthly consumption of chlorinated solvents is 25,000 gal. and of petroleum solvents, 435,000 gal. It is assumed that the amount of solvent purchased and used represents the amount of solvent emitted into the atmosphere. On this basis, solvent emissions from dry cleaning operations are estimated as 5 tons of chlorinated and 45 tons of aliphatic hydrocarbons daily.

The adjustment to be made to these data for the amount of solvent sewered or discarded has not yet been determined. An interesting fact brought out during the survey is that some of the synthetic plant operators dilute their chlorinated solvent with petroleum solvent purchased at retail outlets in order to reduce costs.

SURFACE COATING USERS

The purpose of this survey was to determine the locations of the major surface coating operations and the volume of coatings and organic solvents used in such operations. In planning this survey, eight industrial categories plus a ninth miscellaneous category for a variety of smaller industries were chosen on the basis of suspected extensive spray painting, dipping- or flow-coating operations. Data collected for this survey covered 1955 for the selected industrial companies in the categories of automobile assembly plants, aircraft companies, can and container manufacturers, furniture manufacturers, appliance manufacturers, job enamelers, automobile repainters, plastic products manufacturers, and miscellaneous.

A total of 442 individual plant locations in these nine categories who were contacted by mail and requested to complete a questionnaire form made reply. Of those, only 343 companies were actually engaging in coating processes requiring the use of organic solvents. The companies on the survey list were so chosen as to have, at least, the major companies in each category represented.

Answers to the questionnaire allowed the following data to be accumulated:

1. number and types of coating equipment.
2. hours of operation.
3. air pollution control devices.
4. methods of drying.
5. coatings applied.
6. solvents consumed.

By comparison with data from the Survey of Surface Coating Manufacturers and the, as yet, unreported data from surface coating importers, the 343 companies in this survey who are engaged in coating operations involving approximately 436,000 gal./mo., account for 84% of the industrial surface coatings used in Los Angeles County.

Table 7 is a tabulation by category of industry of the type and volume of surface coatings and organic solvent containing materials used. It also includes the total volume of surface coatings used by each category and per cent of total coatings used by all the 343 companies reporting surface coating operations. Table 8 shows some typical compositions of surface coatings.

Table 9 is a tabulation by category of industry of the classes of organic solvents utilized. The original information in gallons per month is shown as well as the corresponding calculated result in tons per day and percentage of the total. The calculations were made on the basis of a 30-day month. For the 343 companies, an average of 62 tons of organic solvents is employed

PERTINENT DISTRIBUTION DATA ON ORGANIC SOLVENT USAGE IN LOS ANGELES COUNTY

Table 3.—Identity and Sales Volume of Most Used Solvents

Solvent	Approximate sale volume gal./mo.
1. Aliphatic hydrocarbons boiling between 300 to 400° F.	1,000,000
2. Isopropyl alcohol	.......*
3. Ethyl alcohol	.......*
4. Methyl ethyl ketone	.......*
5. Trichloroethylene	200,000
6. Acetone	.......*
7. Methyl alcohol	.......*
8. Toluene	100,000
9. Xylene	100,000
10. Methyl isobutyl ketone	.......*
11. Perchloroethylene	50,000
Total for the eleven solvents	2,650,000

* These volumes withheld to avoid release of confidential, competitive data.

Table 5.—Most Important Purchasers, by Percentages, of Organic Solvents

Category of purchaser	Percentage of total solvents purchased
1. Paint, varnish, enamel, and lacquer mfrs.	36.8
2. Dry cleaners	8.5
3. Rubber products mfrs.	5.6
4. Aircraft companies	6.1
5. Degreasing operators	8.7
6. Service station and misc. retail outlets	4.3
7. Plastics, resins, shellac, and putty mfrs.	4.3
8. Automobile assemblers	3.4
9. Paint and hardware stores	1.7
10. Gasoline additive mfrs.	2.7
11. Drum, can, and container mfrs.	1.7
12. Drug and pharmaceutical mfrs.	1.7
13. Insecticide mfrs.	1.0
14. Lithographers and printing ink mfrs.	0.8
15. Adhesives mfrs.	1.0
16. All others	11.7
Total	100.0

Table 1.—Typical Organic Solvent Uses

Uses			Class of solvents used	Type of solvent action
Manufacture of:			Aliphatic, aromatic, and halogenated hydrocarbons	Dissolving
Paints	Adhesives	Rubber cements		Thinning
Varnishes	Printing inks	Photographic chemicals		Diluting
Enamels	Printing pastes	Insecticides	Alcohols	Dispersing
Stains	Plastics	Toilet preparations	Ketones	Plasticizing
Resins	Rubber	Other surface coatings	Ethers	
Shellac	Gums		Esters	
			Misc.	
Cleaning of:			Halogenated hydrocarbons	Cleaning
Fabrics				Degreasing
Metal surfaces			Aliphatic hydrocarbons	
Manufacture of:			Halogenated hydrocarbons	Surface renovating
Paint and varnish removers				
Manufacture of:			Alcohols	Extraction
Pharmaceuticals		plant extracts	Ketones	Purification
Glandular extracts		food extracts	Ethers	
			Esters	

Table 7.—Consumption of Surface Coatings Containing Organic Solvents *

Category of industry	Type of Surface Coating (gal./mo.) Paints	Varnishes	Enamels	Lacquers	Primers	Misc.**	Total surface coatings gal./mo.	%
Automobile assemblers			54,600	65,100	61,000		180,700	41.4
Aircraft companies	2,300	4,900	400	10,000	800	12,900	30,900	7.1
Can and container mfrs.		9,400	21,500	18,000		17,900	66,800	15.3
Furniture mfrs.		3,800	10,200	27,500	600	10,100	52,200	12.0
Appliance mfrs.		400	22,100	800	12,000		35,300	8.1
Job enamelers			12,600	1,300	400	400	14,700	3.4
Plastic product mfrs.			1,200	600			1,800	0.4
Automobile repainters			5,900	2,000			7,900	1.8
Miscellaneous ***	1,600	11,400	9,100	12,900	2,700	7,900	45,600	10.5
Totals	3,900	29,500	137,600	138,200	77,500	49,200	435,900	100.0

* Tabulation of data for the 343 companies using organic solvents.
** Glazes (700), resins (10,200), sealer (6,800), shellac (300), stain (3,000), zinc chromate (10,000), special coating (17,900).
*** Electronics, adhesives, plating, and machinery manufacturers.

Table 4.—Solvent Usage Distribution

Category of user	Usage in tons/day: Aliphatic and aromatic hydrocarbons	Halogenated hydrocarbons	Ketones, ethers, alcohols, esters, misc.	Total
Paint, varnish, lacquer, and enamel mfrs.	150	1	65	216
Dry cleaners	45	5	(Less than 1)	50
Rubber products mfrs.	30	1	2	33
Aircraft companies	15	1	20	36
Degreasing operators	5	45	(Less than 1)	50
Service station retail outlets	25	0	0	25
Plastics, resins, shellac, putty mfrs.	10	(Less than 1)	15	25
Automobile assemblers	20	(Less than 1)	(Less than 1)	20
Paint and hardware store outlets	10	0	0	10
Gasoline additive mfrs.	0	1	15	16
Drum, can, and other container mfrs.	10	0	3	13
Drug and pharmaceutical mfrs.	1	1	10	12
Insecticide mfrs.	5	0	0	5
Lithographers and printing ink mfrs.	5	0	1	6
Adhesive mfrs.	0	0	5	5
All others	25	10	35	70
TOTAL	356	65	171	592

Table 8.—Examples of Surface Coating Formulae on an As Purchased Basis

Type of surface coating	Composition of surface coating %: Nonvolatile portion	Hydrocarbons aliphatic	Hydrocarbons aromatic	Alcohols	Ketones	Esters and others
Paint	44	56	..	..	..	..
Varnish	50	45	5	..	..	..
Enamel	58	10	30	2	..	..
Lacquer	23	7	30	9	22	9
Metal primer	34	33	33	..	..	..
Glaze	80	..	20	..	..	..
Resin *	50	..	..	..	..	..
Sealer	50	40	..	..	10	..
Shellac	50	..	..	50	..	..
Stain	20	..	80	..	..	..
Zinc chromate	60	..	40	..	..	..

* Contains 50% of solvent of an unspecified type.

Table 6.—Production and Sales Volume of Manufactured Surface Coatings

Name of surface coating	Production gal./mo.	Sales in L.A. County gal./mo.	Sales for industrial spraying gal./mo.	Sales for industrial dip & flow gal./mo.	Sales of water base types gal./mo.
Paints	1,050,000	596,000	42,000	12,000	322,000
Varnishes	407,000	210,000	4,000	1,000	**
Enamels	305,000	208,000	80,000	17,000	**
Lacquers	450,000	288,000	127,000	6,000	**
Others *	472,000	303,000	69,000	26,000	**
Totals	2,684,000	1,605,000	322,000	62,000	322,000

* "Others" comprises stains, sealers, shellac, vinyls.
** None or no substantial water-base production reported.

Table 9.—Consumption of Organic Solvents in Surface Coating Operations

Category of industry	Total of organic solvents used in surface coating operations: Gallons per month	Tons per day	Per cent by weight
Automobile assemblers	213,000	25	40.4
Aircraft companies	82,000	9	14.5
Can and container mfrs.	66,000	8	13.0
Furniture mfrs.	57,000	7	11.3
Appliance mfrs.	25,000	3	4.7
Job enamelers	12,000	2	3.3
Automobile repainters	9,000	1	1.6
Plastic product manufacturers	3,000	< 1	0
Miscellaneous **	61,000	7	11.3
Totals	528,000	62	100.0

* Tabulation of data for the 343 companies using organic solvents.
** Electronics, adhesives, plating and machinery manufacturers.

daily of which 15 tons are aliphatic hydrocarbons; 29 tons, aromatic hydrocarbons; 5 tons, alcohols; 9 tons, ketones; and 4 tons, esters and ethers.

This survey indicates that the six automobile assembly plants rank first in usage of surface coatings and associated organic solvents with 41.5% of the total surface coatings and 40.4% of the organic solvents tabulated for all the categories. Three other categories of industries showing substantial usages are aircraft companies, can and container manufacturers, and furniture manufacturers. If the additional organic solvents used by these categories of industries for other purposes were added to the results of this survey, aircraft companies would probably show the largest consumption of any of the categories. It is estimated that all the organic solvents consumed in the surface-coating operations of these companies would be emitted to the atmosphere except for the minor amounts now being controlled.

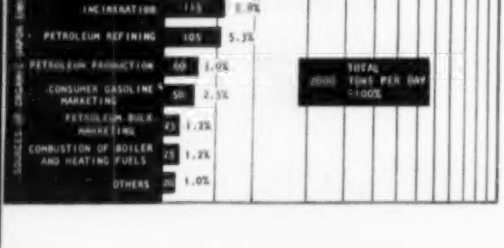
Sources of losses are the evaporation and vaporization of organic solvent during the surface coating application (most commonly by spraying) and subsequent baking or drying. In applying surface coatings by spraying, solvent losses are unnecessarily excessive because of overspray which never impinges on the surface being coated, and so, with its accompanying solvent is wasted. Overspray can amount to as much as 80% or more of the volume sprayed, depending upon the shape and dimensions of the object being sprayed.

Spraying and other surface-coating applications are uncontrolled and the solvent vapors are exhausted to the atmosphere. Use of water curtains in some spray booths is not considered to furnish control for solvent vapors although a small percentage of the solvent might be dissolved in the water and eventually sewered. The only controls so far adopted for surface-coating operations are catalytic combustion units and direct-fired incinerators for baking and drying oven exhaust gases. There have not been enough installations of this kind to achieve any significant reduction in total solvent emissions although local nuisance problems have been alleviated.

Comment

- Approximately 400 of the 600 tons of organic solvents marketed daily in Los Angeles County are released into the atmosphere. This daily emission as shown in Figure 4, represents 20 per cent of all the organic vapors emitted daily into the Los Angeles County atmosphere. Although later refinements proceeding from other scheduled surveys might alter this relationship by a few per cent, the smog-forming potential and quantity of this large mass of air pollution demand the expenditure of intensive control efforts.
- The major sources of organic solvent emissions in Los Angeles County are the aircraft companies, automobile assemblers, rubber products manufacturers, and dry cleaners, and the public. If these are classified by type of operation, then the major sources are in the application and drying of surface coatings, degreasing or metal cleaning, and dry cleaning of clothes.
- No controls are employed for the organic solvents vaporized during the brushing, rolling, spraying or otherwise applying a surface coating, unless the water wash systems used with some spray booths are considered. The primary purpose of such water wash systems is to remove pigment particles from the spray booth exhaust gas stream and no significant collection of solvent is accomplished.
- There are several obstacles to the development of satisfactory control devices or systems. For spray booths, low-solvent concentrations and high effluent volumes as well as small amounts of emissions per individual booth present a real economic barrier. For brushing and rolling, the enormous number of small emitters, not located permanently in any one spot, effectively cancel any real hope of an individual control device. For baking and drying ovens, however, a more optimistic attitude can be taken. Some control installations, operating on a combustion principle, have been made for baking and drying ovens and others are expected. The efficiencies of these are high, better than 90%, where temperatures of the control unit are maintained at a sufficiently high level.
- Some types of industrial degreasers may be said to be operating under semicontrolled conditions, in that they employ cooling coils to condense the solvent vapors which might otherwise overflow the equipment. Nevertheless, a portion of the vapors do escape. The multitude of small operations with individual small losses, widespread locations, and infrequency of many operations hamper quick control.
- Synthetic solvent dry cleaning plants are so designed as to condense and recover for reuse a considerable portion of the solvent. Some of the larger petroleum solvent dry cleaning plants also are so equipped.
- With regard to new techniques, suggestions have been made to employ heat or pressure to create the flowability of surface coatings ordinarily supplied by solvents. Electrostatic spraying has been recommended as a means of reducing overspray and consequent wastage. Another technique, not yet explored, would require enclosure of spraying operations and subsequent reduction of effluent volume and raising of solvent concentration above its explosive limit to make the standard methods of control economically more feasible.
- Reformulated products, eliminating the use of organic solvents and replacing them with water, have been in use for many years for household or architectural structure painting. More extensive use of these products, and development of sister products for industrial coatings, would yield returns not only of less air pollution but also of fewer hazards and possibly lower operating, investment, and insurance costs.
- Besides reformulation of surface coatings to exclude the use of organic solvents, there are other operations involving the use of organic solvents which would be benefited from an air pollution standpoint. Introduction of nonorganic solvent-based degreasing compounds would be one example.
- The enumeration of possible control devices and methods gives hope that a reduction of organic solvent losses in Los Angeles County can be attained. With this in mind, studies are being made of legislation applicable to spraying and baking operations of industrial surface coatings.

Fig. 4. Organic vapor emissions (hydrocarbons, aldehydes, ketones, acids, alcohols, esters, ethers), Los Angeles County, 1955-56. (*Surface coaters, dry cleaners, degreasers, etc.)



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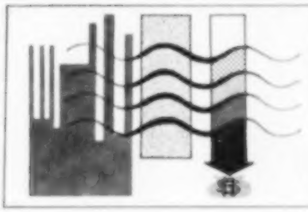

PROFITS FROM WASTE GASES

R. J. Ruff

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Air pollution control obviously requires the removal, collection, or destruction of objectionable contaminants in waste-gases. But what today are frequently considered "waste-gases" from the manufacture or processing of chemicals may well be the source of vast quantities of energy, now recoverable through catalytic oxidation. Increased operating profits resulting from utilization of this energy may be the determining factor in the installation of air corrective equipment. In this way, improvement of community relations becomes a simple by-product of more efficient manufacturing operations. This article presents a few of the operations in the manufacture and processing of chemicals where the Catalytic Fume Combustion Process may serve the dual role of profitable energy recovery and air pollution control.

Since 1949, when the initial Catalytic Combustion Systems were placed in operation in chemical manufacturing processes, a high percentage of the installations have had but one function to fill—economical disposal of combustible contaminants in waste gases. This includes installations in such applications as manufacture of phthalic anhydride, synthetic resins, plastics, synthetic fibers, and the processing of asphalt and coal tar products. Still more diverse have been applications having to do with hydrocarbon, organic, organic nitrogen, and organic sulfur compounds which have been successfully oxidized. The design and operational experiences gained from these early "disposal" systems gives logical sequence to the emphasis now being placed on "profitable recovery" systems.

Catalysts

Catalysts are increasingly being employed for hydrogenation, reduction, and partial oxidation reactions in the manufacture of chemicals. In fume combustion, the catalyst promotes complete oxidation of combustible vapors, even though the temperatures of these gases are very low, and the concentration of combustibles is far below the flammable range. It is therefore a low temperature, flameless means of burning combustible gases to an odor-free, color-free effluent. The temperature required to initiate the reaction on the catalyst varies with the type of hydrocarbon being consumed, but is usually in the 500 to 650° F. range. Through catalysis, therefore, the potential energy of the gases is converted to heat energy, which is then available for recovery. As the combustible constituents in the waste gases are consumed in their passage through the catalyst bed, a temperature rise results, the degree depending upon the concentration of latent energy in the waste gases. The temperature rise obtainable is readily calculated from the heat of combustion of the various constituents and the thermal capacity of the gas stream. The release of each B.t.u. in a cubic foot of 70° F. equivalent air will produce a temperature rise of 55° F., or a fume stream entering the catalyst and containing 10 B.t.u./cu.ft. will increase in temperature by approximately 550° F. as it leaves the catalyst bed.

Catalysts are constructed of the "element" type, similar to that shown in Figure 1, and are similar in appearance to metallic air filter mats. The container screens and the ribbon fill is made of a high nickel alloy, suitable for withstanding temperatures in excess of 1,800° F. These high nickel alloys form the supporting surface area on which is applied platinum alloys which are then conditioned for activity. Elements of standard sizes are employed, and as many of these as are necessary for handling the full volume of the waste gas stream are placed side by side on gasketed framework inside the insulated housing of the fume combustion system. The element construction is light in weight, has high thermal conductivity, low thermal capacity, and low resistance to gas flow. Constructed entirely of metal, the element is unbreakable. There has been no evidence of catalyst spalling or scaling from its supporting base even after 35,000 operating hours. When eventually required, the structure permits reapplication of the catalyst surface at low cost.

Recycling Systems

The basically simple recycling system illustrated in Figure 2 demonstrates the ease with which the heat energy can be released from a waste gas stream and made available for recovery. For initial starting operations, the preheat burner shown brings the system up to the required operating temperature of approximately 600° F. The waste gas stream is then introduced. With sufficient heat released by catalysis, the burner is cut off and thereafter the system is delivering gases at a predetermined temperature to the recovery system on a self-sustaining basis.

A typical application for this system is on the waste gases from the manufacture of formaldehyde from methanol. These gases contain trace amounts of formaldehyde and methanol which may, on occasion, cause neighborhood complaints. The

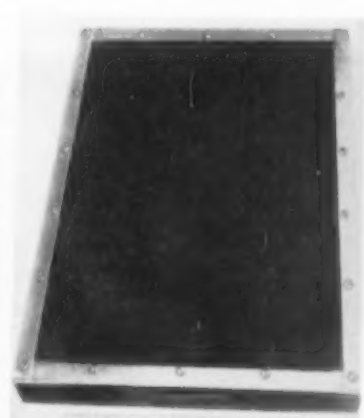


Fig. 1. Photo of catalyst "element" shows similarity to metallic air filter mats.

* Mr. Ruff is President.

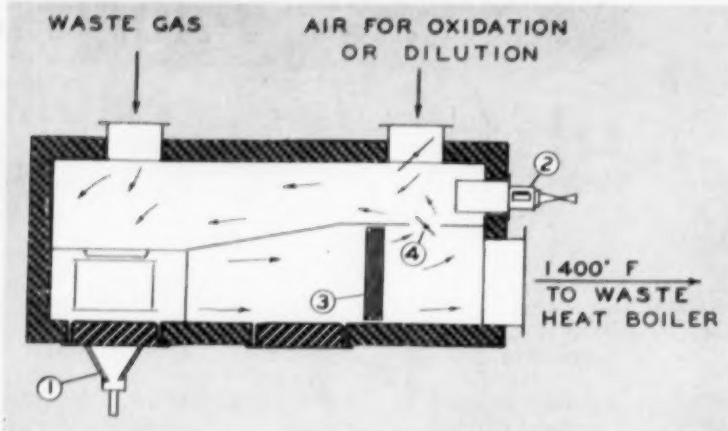


Fig. 2. Recycling system. 1—fan; 2—preheat burner; 3—catalyst; 4—recycling damper.

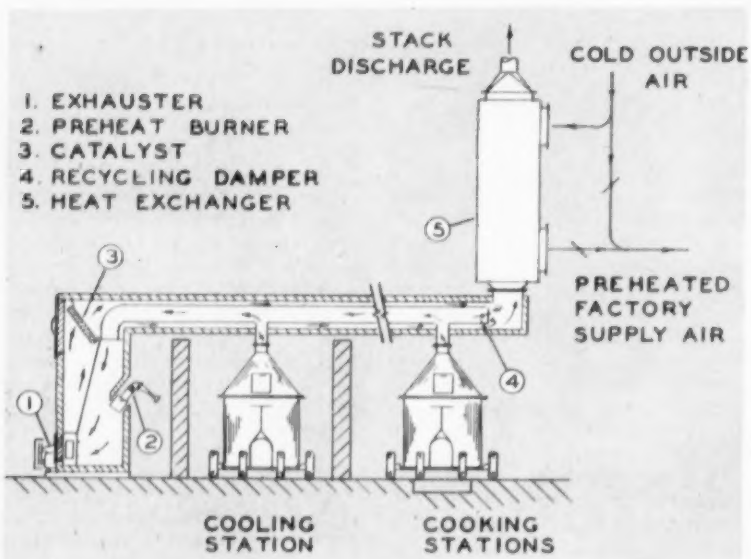


Fig. 3. Integration of fume disposal from a kettle cooking operation with factory make-up air heating.

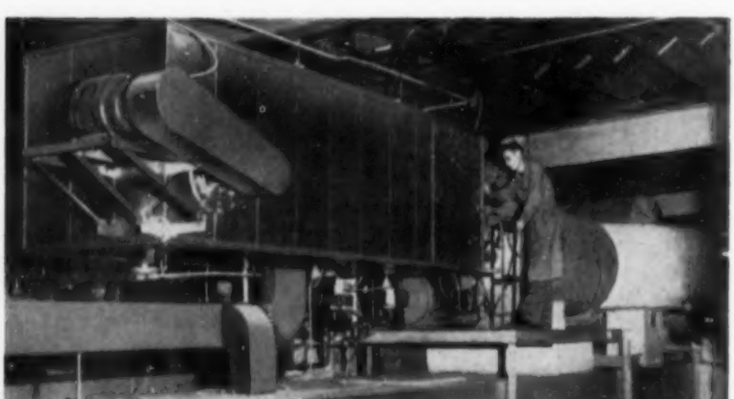


Fig. 5. Typical catalytic heater for ovens and dryers.

amount of energy represented by these constituents is small by comparison to the hydrogen and carbon monoxide also present in the waste gas. The total energy in the waste gas stream may be as high as 60 B.t.u./cu. ft. If only sufficient air is added to provide the needed oxygen, the mixture is usually slightly below the lower flammable range, and therefore would normally not sustain flame burning. With the arrangement shown in Figure 2, the air required for oxidation is preheated by the recycled stream. Both of these streams serve to dilute the energy in the waste gases so that the concentration entering the catalyst may now be in the range of 15 B.t.u./cu. ft.

For variations in volume or energy of the waste gases, control of the catalyst discharge temperature can be maintained by varying the volume of recycled or fresh air employed. For a formaldehyde plant of common size, as much as 6 million B.t.u./hr. of heat energy is available for the heating of warehouses, factory make-up air, or for boiler operations.

The recycling system has similar profitable application when handling the waste gases from a carbon generating plant, using either natural gas or fuel oil as feed stock. Here, the waste gases contain trace amounts of carbon, but the major potential energy results from the presence of hydrogen and carbon monoxide. Typical analysis shows an energy concentration in the range of 35 B.t.u./cu. ft. A normal size carbon plant may have 25,000 cu. ft./min. of these waste gases, which represents a potential available energy approaching 90 million B.t.u./hr. While such high losses of resources to the atmosphere may appear fantastic, the values become realistic upon appreciation of the fact that four atoms of hydrogen must be released to produce an atom of carbon from natural gas.

Factory Heating Applications

In any enclosed factory area where large amounts of ventilation are employed, it is usual practice to install makeup air supply fans for replenishment of exhausted air. During the colder seasons of the year, preheating of this makeup air will provide the major portion (if not all) of the factory heating demands. Integration of fume disposal from a kettle cooking operation with factory make-up air heating is shown in Figure 3.

Batch-type kettle cooking operations are frequently employed in the manufacture of paints, resins, foundry core oils, waxes, some food products, and in heat processing of animal, vegetable, or mineral oils. The high temperature oxidized gases resulting from the burning of the fumes released during these kettle cooking operations are directed through an air-to-air heat exchanger, before being released to the atmosphere, as shown on the diagram. Cold outside air is drawn across the shell side of

the exchanger and preheated before being supplied to the plant distribution duct work. Automatic temperature controls regulate a by-pass damper to maintain a predetermined makeup air supply temperature through variations in outside air temperature or release rate of fumes. During portions of the cooking cycle, when fume release rate is low, the preheat burner can be employed to supplement the fume energy so as to maintain makeup air supply temperature during the coldest weather conditions.

A slight modification of Figure 3 is employed by one manufacturer of synthetic resins. Instead of being employed for factory make-up air heating, the exchanger is designed to deliver preheated air at approximately 400° F. for an adjacent pigment dryer.

Arrangements similar to Figure 3 have also been employed in a number of cases for the primary function of recovering sensible heat from furnace exhaust gases. In this case the total available heat represented by the temperature of the exhaust gases is higher than the latent heat obtainable from the combustion of the entrained fumes.

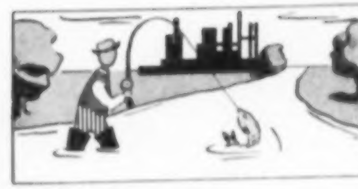


Fig. 6. Catalytic pressure reactor with top shell removed to expose the hollow cylindrical catalyst media.

Heat Curing or Baking Operations

There exists in the chemical process industries a wide variety of drying, baking, or curing operations where heated air is employed for vaporization of hydrocarbon and organic materials. This includes the drying of alcohols from granulations, the baking of industrial finishes, the heat curing of resin coatings and impregnants on paper and fabric products. In a high percentage of these types of applications, the heat of combustion contained in the solvents presently being exhausted to the atmosphere is more than sufficient to cover the heating demands of the oven or dryer. As an example, a 90 foot "treater" for the curing of a phenol formaldehyde resin impregnant in paper products has a heat demand of 5 million B.t.u./hr. The heat of combustion represented by the 60 gal./hr. of solvents released during the treating operation under average running conditions is 7 million B.t.u./hr. It becomes obvious, therefore, that the treater can literally be "run by its tail gases" with no external heat required whenever volatiles are being released in the process.

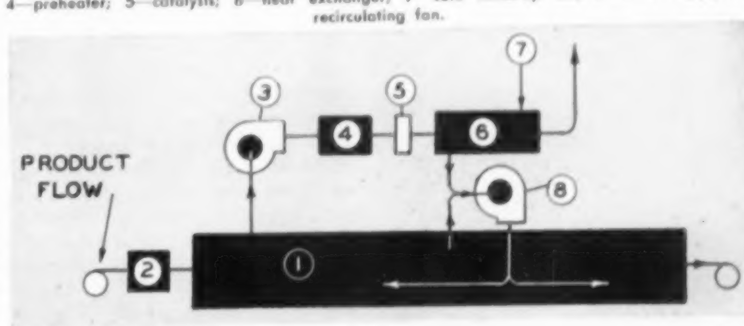
The manner in which catalytic heat recovery can be employed on a continuous heat curing operation is shown in the accompanying flow diagram (Figure 4). The oven exhaust gases are discharged through a heater containing catalysts and heat exchanger. During the starting operations, the burner shown provides the necessary heat to bring the oven to operating temperature. Thereafter, all heat required to maintain the oven operating temperature is obtained by catalytic oxidation of the gases exhausted from the oven. When, for any reason, the volatile release rate is low, the burner automatically makes up for any deficiency. Otherwise, the excess heat generated at the catalyst, beyond the needs of the oven, is either released to the atmosphere or directed to factory makeup air heaters, with the oven maintained under controlled temperature as required for the curing process. A typical catalytic heater for ovens and dryers is shown in Figure 5.

Catalytic Pressure Reactors

In recent years there has been an increasing tendency among designers of chemical plants to employ elevated pressures for the manufacture of nitric acid, ethylene oxide, and other chemicals employing gas-phase reactions. Power costs for gas compression are higher, but this is more than offset by reduced plant cost per ton of product produced. However, since introduction of catalytic pressure reactors, even plant power cost now compares favorably with older, low pressure plants.

Basically, a catalytic pressure reactor consists simply of a vessel constructed for the pressures and temperatures anticipated, and containing an oxidizing catalyst arranged to accommodate maximum throughput capacity at minimum resistance to flow. It might also include starting preheaters to bring the system to initial reaction temperature, fuel addition system for energy enrichment of the tail gas as may be needed to maintain constant vessel outlet temperature or control by-pass system, and necessary safety and interlocking circuits. Such a reactor (with top shell removed to

Fig. 4. Catalytic heat recovery in a continuous heat curing operation. 1—continuous curing or baking oven; 2—product impregnation, dip, roller coat, spray; 3—oven exhauster; 4—preheater; 5—catalysts; 6—heat exchanger; 7—cold make-up air; 8—oven supply or recirculating fan.



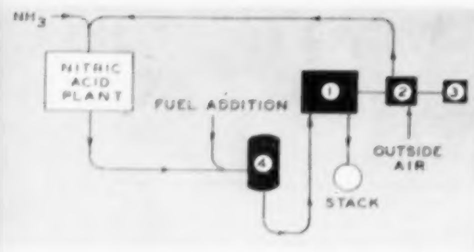


Fig. 7. Flow arrangement for catalytic power recovery in a nitric acid plant. 1—turbine; 2—air compressor; 3—starting motor; 4—catalytic reactor.

expose the hollow cylindrical catalyst media) is shown in Figure 6.

When employed on the pressurized tail gas of an ethylene oxide plant, the gases may be delivered to the vessel at temperatures in the range of 400° F. and at pressures of 100 lb./sq. in. gauge or more. Sufficient ethylene, ethane, and other combustibles are present in the waste gas stream so that upon combustion in the catalyst, vessel outlet temperatures are maintained at temperatures of 900 to 1,200° F. or more, depending upon the specific plant design. These gases then pass through a gas turbine where the power generated is delivered to the gas compressor.

Catalytic Pressure Reactors for Nitric Acid Plants

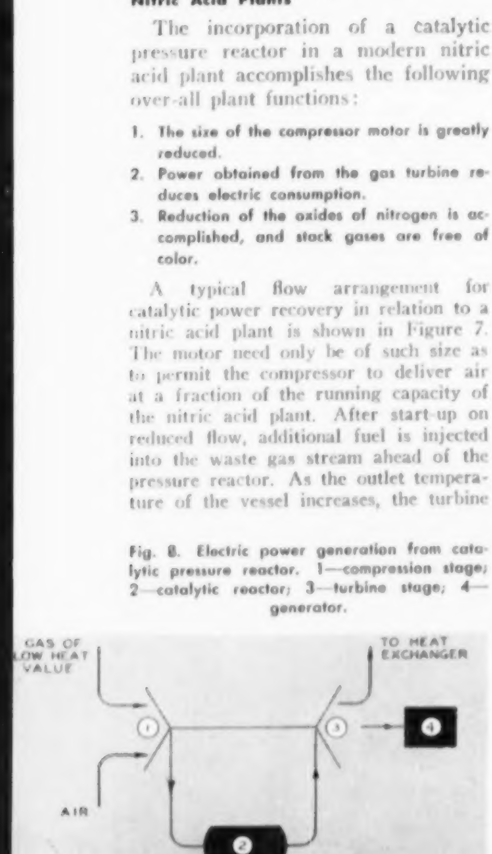
The incorporation of a catalytic pressure reactor in a modern nitric acid plant accomplishes the following over-all plant functions:

1. **The size of the compressor motor is greatly reduced.**
2. **Power obtained from the gas turbine reduces electric consumption.**
3. **Reduction of the oxides of nitrogen is accomplished, and stack gases are free of color.**

A typical flow arrangement for catalytic power recovery in relation to a nitric acid plant is shown in Figure 7. The motor need only be of such size as to permit the compressor to deliver air at a fraction of the running capacity of the nitric acid plant. After start-up on reduced flow, additional fuel is injected into the waste gas stream ahead of the pressure reactor. As the outlet temperature of the vessel increases, the turbine begins to deliver shaft power to the compressor. In this way, the full rated flow of the plant is built up. The vessel outlet temperature is maintained by automatic control of fuel addition to maintain design temperature on the turbine.

In the above example, an electric motor was used for starting purposes. On another installation, initial starting was accomplished by a small steam turbine, which was then disconnected as the gas turbine took over the power needs.

Fig. 8. Electric power generation from catalytic pressure reactor. 1—compression stage; 2—catalytic reactor; 3—turbine stage; 4—generator.



The ratio of total plant power obtained from the gas turbine depends upon the permissible operating temperature for the turbine as well as other plant design factors. Based upon the limited information so far available, it appears that approximately 60 per cent of the total plant power can be recovered with a 900° F. turbine, and higher percentages with higher permissible turbine temperatures. Reactors for gas turbines delivering 1,700 hp. are in use, and substantially larger reactors are being designed.

Decolorizing of the stack gases is attained by the action of the fuel addition upon the oxides of nitrogen present in the waste gas as they pass through the catalyst media. The actual mechanism of the reaction is not entirely clear, but it is believed that preferential oxidation causes reduction of the oxides of nitrogen with simultaneous oxidation of the fuel addition. This belief is reinforced by results currently being obtained in the decolorizing of other waste gases at atmospheric pressure, and containing high concentrations of oxides of nitrogen.

Pressure Reactors for Gas Turbine Power Plants

From a power generating standpoint, the setup illustrated in Figure 7 differs little from a conventional gas turbine as used purely for power generation, except that a manufacturing operation is added between the compression stage and the turbine stage. It is not the scope of this paper to suggest catalytic methods of combustion for stationary-type gas turbine power generating systems when fired by conventional oil for gas fuels having high heats of combustion. However, where large volumes of process exhaust gases are available at low pressure, low temperature, and with heats of combustion only slightly above or below the lower flammable range, excellent opportunities exist for electric power generation by using a catalytic pressure reactor similar to that previously described, but with flow arrangement similar to that illustrated in Figure 8. The designation "gas of low heat value" as shown on the figure may consist of any hydrocarbon or organic gas having fixed or variable heat of combustion, ranging perhaps from 20 to 100 B.t.u./cu.ft. or more, which otherwise would be difficult to burn by conventional firing means. The conventional compression stage of the turbine is employed to bring these gases as well as excess air to the final pressure employed at the catalytic reactor. The amount of gas added to the air during the compression stage is controlled to maintain the desired turbine inlet temperature. Temperatures as high as 1,450° F. or more may be delivered to the turbine, depending on turbine design.

Catalyst Life

Were it not for the presence of inorganics, it is believed that the activity life of the catalyst would outlast any of the related equipment in which it is installed. However, since all gases contain certain amounts of fine dust, fly ash, and other inorganic particles, some coating, as well as attrition, of the active surfaces will eventually occur. Where installations are operating at atmospheric pressure, the catalyst can easily and conveniently be removed for periodic washing of the surface contamination. When maintained in this manner, good activity has been retained without factory service to the catalyst for periods exceeding 35,000 operating hours. When needed, the catalyst elements are returned to the factory for reapplication of a new coating of the catalyst for a second lifespan. Similar service is expected of catalysts in pressure reactors. In a nitric acid plant, where air must be reasonably free of contamination, catalytic reactors continue in use after 30 months of service-free operation. Whenever needed, gas precleaning can be employed to remove contamination or to further extend the interval between service requirements.

The question occasionally arises as to the resistance of the catalyst to "poisoning" agents. Vaporized metals, such as mercury, lead, and zinc, if present in the gases, can cause material reduction of catalytic activity. The presence of these metals in sufficient quantity to cause damage is, however, extremely rare, and the applications are usually recognizable in advance. The catalyst media have been extensively employed for oxidation reactions on organic nitrogen and organic sulfur compounds, which have no harmful effect.

Presented at Industrial Pollution Control Symposium, A.I.Ch.E., Akron, Ohio.

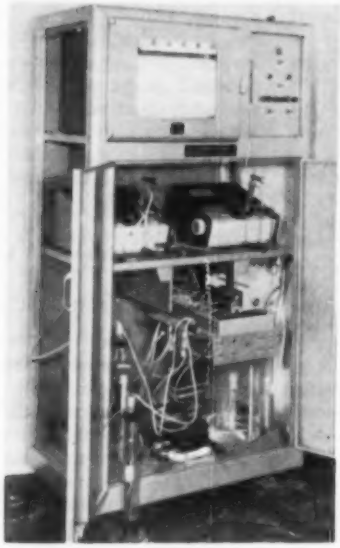


Fig. 2. Austin dual colorimeter.

HIGH SENSITIVITY CONTINUOUS INSTRUMENTATION for ATMOSPHERIC ANALYSES

Lewis H. Rogers | Air Pollution Foundation, San Marino, California

Application of continuous recorders to air-pollution work is a special field in which high sensitivity is frequently the most important design criterion. The accompanying article gives methods for improving sensitivity and cites examples of instruments using these procedures to illustrate developmental trends. Most of these instruments could be used for process stream analysis.

Application of automatic devices for recording concentrations of trace materials both in enclosed spaces and in the open atmosphere is a rapidly expanding field. All continuous recorders are derived from laboratory analytical procedures which in most cases can be made automatic. Many of the instruments used for measuring low concentrations of pollutants in air have applicability for process stream analysis and control. Continuous-recording devices are used in air pollution work for one or more of the following reasons: safety—that is, to measure exposure of persons to toxic or potentially toxic concentrations of injurious materials; protection from legal action; reduction of manpower requirements of manual measurements; following diurnal and long term trends of pollution; studying atmospheric reactions.

There have been a number of recent reviews of recording instruments as well as manual procedures for carrying out air-pollution studies. Those by Patterson (*8*), Cadle, *et al.* (*3*), Cholak (*4*), and Yaffe, *et al.* (*14*), are especially useful. Renzetti and Rogers (*10*) and Bryan and Romanovsky (*2*) have described the instruments which are used for air measurements in the Los Angeles area.

This paper reviews briefly some of the recording instruments which have recently been applied to atmospheric measurements. Instruments are described which illustrate what appear to the author to be trends of new developments.

The desiderata governing the trends in design and development of continuous atmospheric analyzers are: increased sensitivity—that is, lower limit of detectability; decreased sampling period; decreased cost; improved reliability. Of these, sensitivity is often the most important criterion in selection or design of an instrument.

Methods of increasing sensitivity include: increase in sample size with constant reagent volume; use of increased pressure; extension of the light absorbing path length; use of selective reagents. Newer instruments

Fig. 1. Recording colorimeter.

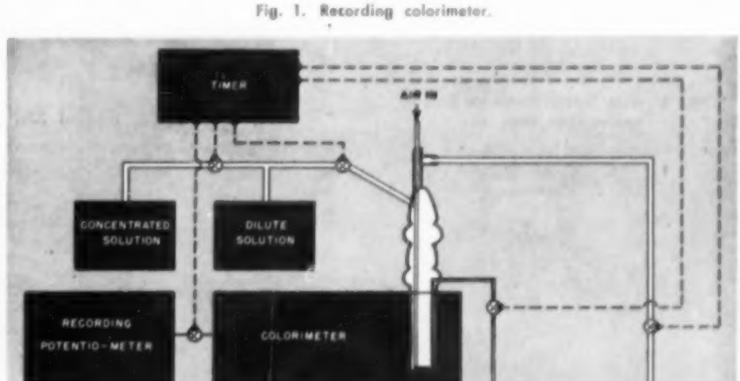


Table A.

		p.p.m.
Hexane	=	1.00
Octane	=	1.32
Octene-1	=	0.78
Hexene-1	=	0.50
n-Butane	=	0.67
Butene-1	=	0.35
Ethane	=	0.39
Ethylene	=	0.02
Acetylene	=	0.0018

which utilize these various methods are discussed here.

Increased Sensitivity with Increased Sample Size

AUSTIN DUAL COLORIMETER

Since the previous review by Renzetti and Rogers (*10*), additional information and experience have been obtained with the Austin Dual Colorimeter (*1*). Austin designed and built an instrument of the "batch" type, in which a measured volume of air was reacted with a measured volume of reagent, the optical density of reacted solutions was recorded, and the solution was then automatically discarded. In effect, this principle involves converting manual, batch sampling and analysis to automatic batch sampling and recording.

The instrument was designed for use with two oxidant reagents: namely, the phenolphthalin reagent used by Haagen-Smit as described by McCabe (*6*), and the ferrous thiocyanate reagent as described by Todd (*12*). Results obtained with both these reagents have been shown to have value in air-pollution studies. The instrument as constructed recorded the results of five separate analyses with each of the two reagents during each hour. A schematic diagram of one side of this instrument appears in Figure 1 and a photograph in Figure 2.

The air samples were contacted with the reagents in an impinger built into a test-tube-shaped absorption cell which was placed in the cell holder of a Beckman Model C colorimeter. Measurement of the transmission of the reagent solutions were made before and after sampling and automatically recorded on a strip chart recorder. The two colorimeter readings were recorded on the same strip chart in sequence. By means of critical orifices downstream from the impingers the air sample was metered. The flows of air and solution were controlled by actuation of solenoid valves and solenoid-operated syringe pumps in the proper sequence. A programming shaft with several cams driven by a synchronous motor automatically actuated the various syringe pumps and valves through cam-driven microswitches. For one cell and one cycle the sequence of operation was: rinsing of the cell with reagent; making up the reagent charge; recording the blank; reacting a measured air volume with the reagent; recording the resulting color; and draining the cell. Small Bunsen check valves in the fluid lines prevented reverse flow.

The reagents were made up in the form of two concentrated stock solutions for each side of the instrument. The two stock solutions were metered and diluted in the feed line to the absorption cell. In this manner, the deterioration with time of the mixed reagent solution was avoided to a great extent.

This unit was designed to give a wide selection in air:reagent ratios, and hence should be applicable to other reagents. For example, it should be useful with a minimum of modification to measure oxidants with potassium iodide; nitrogen dioxide with modified Griess reagent; sulfur dioxide with disulfitomercurate (*13*), and with other colorimetric reagents. Furthermore, by changing the cams it would be possible to sample once per hour or at some other frequency if this should prove desirable. With an increase in the volume of sample to reagent ratio, increased sensitivity can be achieved.

Increased Sensitivity with Increased Pressure

L.I.R.A. HYDROCARBON ANALYZER

This unit is almost identical to the L.I.R.A. carbon monoxide analyzer (Figures 3 and 4). It is a nondispersive infrared analyzer, calibrated for a range of 0-3 p.p.m. hydrocarbons with the use of hexane as a sensitizing material. The instrument pressurizes the sample to 175 lb./sq.in. and the sample cells are heated to a temperature of 150° F. Its sensitivity to hydrocarbons is stated by the manufacturer * to be as shown in Table A.

Increased Sensitivity with Increased Light Path

FILTER PHOTOMETER FOR HYDROCARBONS

This unit,† built as an experimental device, has been briefly tested by Stanford Research Institute in South Pasadena. While additional development is desirable, the experimental model has considerable promise for use as an air monitoring tool.

The instrument consists of a photometer assembly, 2-meter absorption cell, and associated electronics and power supply. It was designed for a minimum detectability of 0.1 p.p.m. hydrocarbon in air as hexane, and full-scale range to 3 p.p.m. The photometer assembly includes

* Mine Safety Appliances.

† Built by Perkin Elmer Corporation.

Fig. 4. Mine Safety Appliance L.I.R.A. hydrocarbon analyzer.

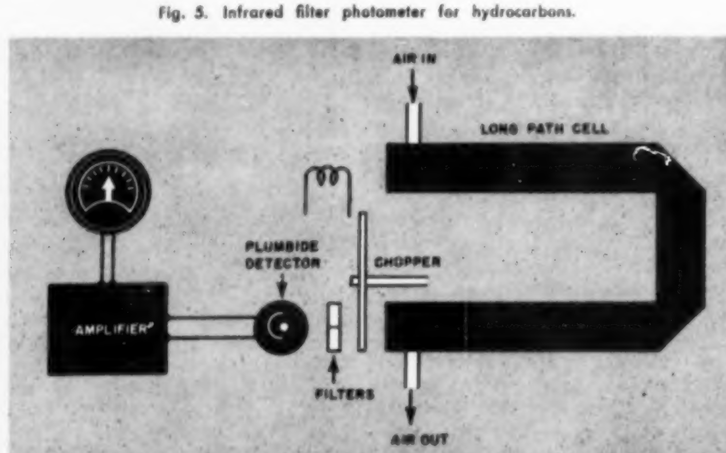


Fig. 5. Infrared filter photometer for hydrocarbons.

a light source and chopper, analytical and reference filters, null balancing device, and Kodak plumbide detector. Operating as a double-beam instrument, the analytical filter is centered on the characteristic absorption band of hydrocarbons at 3.4μ, and the reference filter is centered at a near-by wavelength where there is no absorption. The 2-meter sample cell is a 4-in. aluminum tube, one meter long, in which a folded optical path achieves the 2-meter path length.

The instrument shown in Figures 5 and 6 is considered to be still in its developmental state, and several improvements are planned to increase stability and sensitivity. These improvements involve mechanical, optical, and electronic changes, the combined effect of which should result in a useful air monitoring instrument.

Increased Sensitivity with Selective Reagents

UNSATURATED HYDROCARBON RECORDER

An instrument ‡ for recording the concentration of unsaturates in the range of 1 to 200 parts per hundred million is based upon the reaction between unsaturated hydrocarbons and heated mercuric oxide. The reaction produces one mole of mercury vapor per mole of mono-olefin. The mercury vapor is measured with a sensitive ultraviolet photometer. There is no response to saturated hydrocarbons and only slight response to aromatic hydrocarbons. A schematic diagram of the instrument is shown in Figure 7.

The sample enters the instrument and passes through silver oxide to remove carbon monoxide and hydrogen. The sample stream is then divided and one part passes over heated mercuric oxide and then to an optical cell in the ultraviolet photometer. The other half of the stream passes through a

‡ Developed by Harold Kruger.

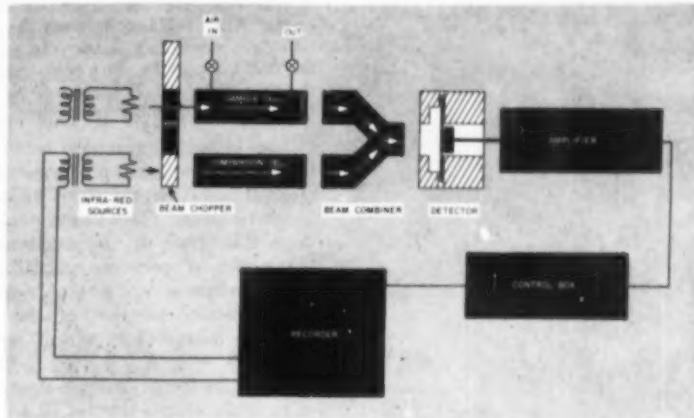


Fig. 3. L.I.R.A. pressurized hydrocarbon analyzer.

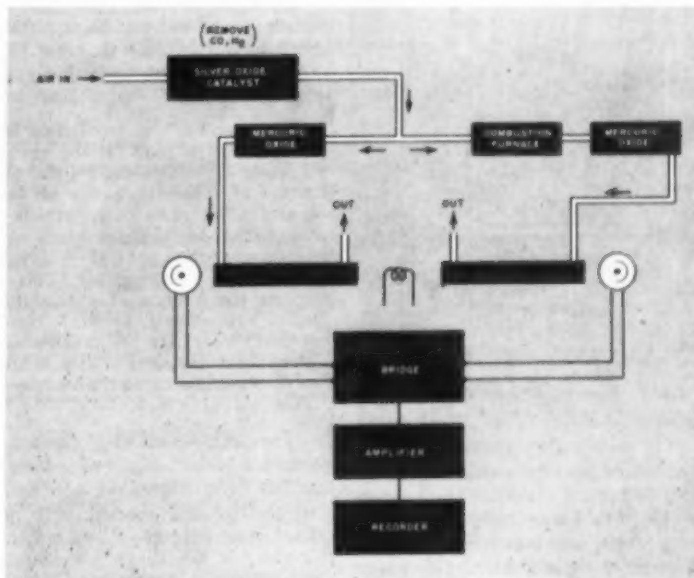
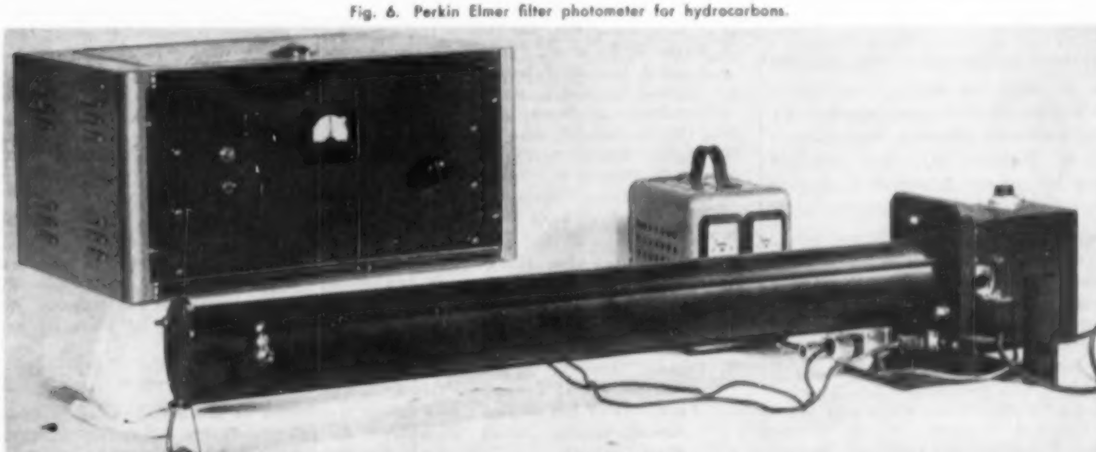


Fig. 7. Kruger unsaturated hydrocarbon recorder.

Fig. 6. Perkin Elmer filter photometer for hydrocarbons.



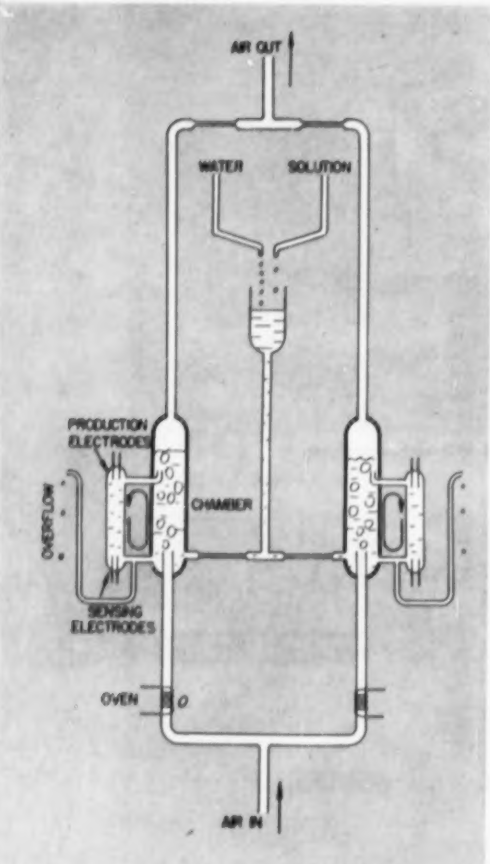


Fig. 8. Regener differential coulometric ozone analyzer.

combustion unit to oxidize hydrocarbons to carbon dioxide. The oxidized sample then passes over heated mercuric oxide and into a reference optical cell in the ultraviolet photometer. The phototubes are connected in a bridge circuit and their output is fed through an amplifier to a recorder. Periodically, the recorder corrects for any shift in zero or sensitivity of the photometer.

Differential Coulometric Ozone Analyzer

A recorder for atmospheric ozone which discriminates against other atmospheric oxidants has been developed by Regener (*9*). The principle of the instrument is shown in Figure 8.

Outside air enters at the bottom in the diagram and then divides in equal parts to the right and left. The air may be heated to a temperature of about 300° C. by each of the electric ovens. At this temperature ozone is dissociated, and it is this specific property of ozone which is used here to discriminate against other atmospheric components which may affect the chemical reaction. If one of the heaters is on and the other off, the air stream which has been heated is free of ozone. After bubbling through the reaction chambers the air is removed through the outlet shown at the top in Figure 8. A flow rate of 7 liters of air/min. through each chamber is used.

The chemical reaction is of the iodine type; ozone produces iodine quantitatively from the potassium iodide solution. The addition of sodium thiosulfate to the potassium iodide solution prevents volatilization of the iodine and allows an accurate amperometric detection of the end-point by means of a pair of sensing electrodes.

The quantity of sodium thiosulfate in each chamber is titrated by a coulometric production of iodine from the iodide solution with a current which passes through a separate pair of production electrodes. This method of determining sodium thiosulfate has been used for some time by Ehmert (*5*) in a manual method for ozone determinations.

The current flowing through the sensing electrodes as a result of the production of iodine is used to control the concentration of iodine by means of a servo system. The servo loop consists of a commercial d.c. amplifier which employs a chopper at the input and which operates directly into a servo motor. This motor adjusts the position of a potentiometer in such a manner as to increase the current through the production electrodes when the iodine concentration is low and to decrease this current when the iodine concentration is high.

The iodine-producing current is a measure of the amount of sodium thiosulfate which enters per unit time and which has not reacted with iodine from other sources. When only one of the ovens is on, any ozone present is destroyed in that half of the air stream, but will liberate iodine from the iodide in the other half of the air stream. The difference between the two production currents which develops is a direct measure of the amount of ozone present. It is this difference in the two production currents which is recorded on a strip chart recorder.

Future Trends

More elaborate instruments which give information on several pollutants simultaneously are becoming available.

A mass spectrometer which takes samples periodically and records the results automatically has been used for process streams for several years (*7*). Similar applications have been made elsewhere. It is also easy to imagine an automatic multichannel long path infrared spectrometer for measurement of atmospheric pollutants. Automatic gas chromatographs are now commercially available (*11*). This trend toward greater elaboration of instruments, with the resulting increased information, is a normal development in a field in which so little is known and understood.

The use of more complicated instruments has two unfortunate aspects: namely, the increased cost of each unit, and the inevitable requirements for better trained personnel. The cost of the abatement of the obnoxious effects of air pollution is the price that must be paid for increased industrialization and for crowding more people and more motor vehicles into each square mile. It appears to be an inherent concomitant of our increasingly complex civilization.

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With adequate means of measurement and systematic investigations evaluated on a generalized basis, much more advantage could be obtained from a theoretical knowledge of the existing methods of dust collection, and it is quite likely that such investigations will lead to the development of vastly improved methods which are presently unsuspected. The accompanying article summarizes the basic performance principles of dust collection equipment, discusses the major problems in measurement techniques, and indicates areas for potential development.

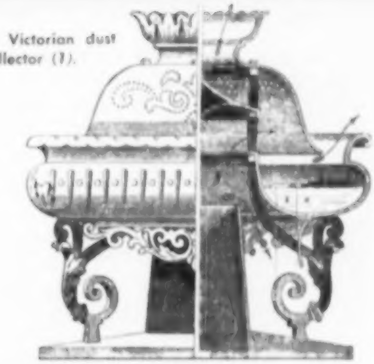


Fig. 1. Victorian dust collector (*1*).

a critique on the state of the art of DUST AND MIST COLLECTION

K. E. Lunde and C. E. Lapple | Stanford Research Institute, Menlo Park, California

A cursory comparison of current dust collection equipment with that available in 1907 might tend to leave the impression that little has been accomplished in the past fifty years. This is, of course, by no means the case, and many improvements in design have occurred in this period.

In the case of cyclones, the major accomplishment has been the recognition that, at least with nonflocculated dusts, efficiency can be improved by the use of small-diameter cyclones. In the case of bag filters, the availability of synthetic fibers in particular has enabled considerable extension of the temperature range in which they can operate. Shaking mechanisms have certainly improved, and reverse jet devices have been made practical for at least relatively large-scale operation. The availability of ultrafine fibers has made highly efficient collection of submicron particles possible with thin filter beds. Scrubbers have shown an increasing tendency toward simplicity of design, and new materials of construction have made them adaptable to highly corrosive services. Electrostatic precipitators have benefited from improved rectification equipment, electrode designs, and rapping mechanisms. Maintenance costs for dust collection equipment in general have probably been greatly reduced, but there have been no radical improvements in performance, as measured by efficiency, power consumption, and, probably to a large degree, capital investment.

Important as are the advances which have taken place, the increasingly rigid air pollution requirements confronting industrial operations demand better dust collection equipment, from the standpoints of both efficiency and cost. It is, therefore, important to inquire as to why we do not have such equipment available. One reason is that no new principles have been discovered; even the flocculation of aerosols by sound waves was recognized in the nineteenth century. New principles are exceedingly rare, and discovery of them certainly cannot be anticipated with confidence. Another reason is that we are not yet able to predict adequately the performance of even established equipment, much less proposed equipment. Figure 1 (*1*) is an illustration of this point. As the inventor conceived the operation of this device, the smoke emerged from the chimney and had an opportunity either to by-pass the device completely or to pass over, but not through, a pool of rainwater. The inventor stated only that in passing over the water the smoke would lose *some portion* of its soot. How much more quantitatively can one predict the performance of even this extremely simple device today?

What is the necessity of being able to predict the performance of dust collection equipment? Usually the proposed equipment can be experimentally tested on the dust in question, and selection can be made on the basis of its performance. On the other hand, pilot plant evaluations of dust collection equipment, like any other pilot plant work, can be extremely costly; thus this factor alone frequently reduces the variety of equipment potentially available which is actually evaluated in practice. Consequently, one is rarely sure that the most effective or economic equipment is actually installed. Also, unless pilot plants are operated over a wide range of variables, important trends may be masked by variations in the conditions encountered. Moreover, circumstances may be such that no experimental program is possible prior to the construction of full-scale equipment. However, the most important advantage of prediction of the performance of dust collection equipment is that this would probably provide the greatest opportunity for substantial improvements in efficiency, power requirements, capital costs, and probably maintenance.

Obviously, in order to be able to predict the performance of an actual or proposed design of equipment, one must have a theoretical or at least rational basis for generalizing the factors encountered. Considerable progress has been made in developing the theory of the mechanisms of dust collection. But much remains to be done, especially an adequate follow-up of the theoretical developments already evidenced.

It is the purpose of this paper to

HISTORICAL NOTE

Fifty years ago the last principal type of dust collection equipment in use today was successfully applied to an industrial problem. F. G. Cottrell in a matter of a few months designed and constructed an electrostatic precipitator for the removal of fumes from the ventilation gases of a gold-silver parting furnace at the Selby Smelter near San Francisco. Even then the concept of electrostatic precipitation was old, probably first being suggested by Hohlfeld in Germany in 1824. In the meantime considerable work on the subject had been carried on, principally by Oliver Lodge, but Cottrell's use of high voltage direct current finally made the process feasible for industrial application. All other types of presently used dust collection equipment preceded the successful application of electrostatic precipitation. Cyclones found their principal use in woodworking plants until about 1905 when they were utilized for cleaning blast furnace gases. Bag filters are of at least equal age, and probably much older. Even reverse flow filters were in use by 1893. A myriad of scrubber designs was in operation by the turn of the century, and at least one was capable of collecting dust with efficiency equal to that of any in common use today (3, 6, 11).

discuss in a general way the status of theoretical knowledge, the major problems in measurement techniques, and the manner in which these may influence the design, development, and application of dust collection equipment.

Status of Theoretical Knowledge

MECHANISMS IN DUST COLLECTION

The basic mechanisms operative in any dust and mist collection device may be categorized into three distinct phases: (1) deposition of suspended particles on a collecting surface; (2) retention of the deposit on the surface; and (3) removal of the deposit from the surface.

The over-all equipment performance reflects the net composite result of these three phases. The particles must first be separated from the gas stream, which ultimately means deposition of the particles on a liquid or solid surface. Once the particles are deposited on the surface, they may not be considered collected unless they remain there until intentionally removed. If, after deposition, the gas stream reentrains the deposit, collection has not taken place. The final phase involves removal of the retained deposit from the collecting surface to suitable storage or disposal. In some instances, as in throwaway air filters, this may take the form of physically replacing the collecting surface.

Although some of these phases may appear as relatively trivial physical operations in some instances, they may represent controlling performance limitations in others. For a general and ultimate rationalization of collection equipment design, it is essential that all three phases be clearly recognized, as well as any interactions between them. This will be illustrated by some of the specific examples cited in the subsequent discussion.

A. DEPOSITION MECHANISMS

1. Basic Mechanisms

In order to separate suspended particles from a gas stream, it is necessary to provide (1) a force (or pseudoforce, such as momentum change), so directed as to cause a differential motion of the particle relative to the gas, (2) a collecting surface upon which the migrating particle can deposit, and (3) sufficient gas retention to permit the particle to migrate to the collecting surface.

The six known mechanisms by which suspended particles can be caused to deposit on surfaces are summarized in Table 1. The inherent effectiveness of deposition by each mechanism is measurable in terms of a dimensionless parameter (*4, 5, 7, 8, 10, 13, 14*) which incorporates the major aspects of the respective forces and retention times involved as determined by the equipment operating conditions and size scale. This is termed "basic parameter" in Table 1. In the case of some mechanisms, the magnitude of the forces involved is influenced also by other factors, related specifically to the mechanism. These factors are termed "specific modifying parameters" and in combination with the basic parameter measure the over-all inherent effectiveness of the mechanism.

Although the above combination of basic and specific modifying parameters measures the inherent effectiveness of each mechanism, the actual deposition efficiency that is realized in a specific application is also a function of additional factors related to the system. The influence of these additional factors may be described or measured in terms of what may be termed "system parameters." These additional "system" factors and the corresponding system parameters are summarized in Table 1 and are discussed below:

Equipment Geometry: Although the scale factor is normally incorporated in the basic mechanistic parameter discussed above, variations in geometric proportions are not. These may be allowed for by

Table 1.—Summary of Mechanisms and Parameters in Aerosol Deposition

Deposition mechanism	Origin of force field	Deposition mechanism measurable in terms of: Basic parameter	Deposition mechanism measurable in terms of: Specific modifying parameters	System parameters
Flow line interception †	Physical gradient †	$N_{sf} = \left(\frac{D_p}{D_b}\right)$	$N_{ss} = \left(\frac{N^2_{sf}}{N_{si}N_{sd}}\right) = \left(\frac{18\mu}{k_m\rho_p D_v}\right)^{**}$	Geometry: (D_{b1}/D_b), (D_{b2}/D_b), etc. ϵ_v α
Inertial deposition	Velocity gradient	$N_{si} = \left(\frac{k_m\rho_p D_p^2 u_o}{18\mu D_b}\right)$		
Diffusional deposition	Concentration gradient	$N_{sd} = \left(\frac{D_v}{u_o D_b}\right)$		
Gravity settling	Elevation gradient	$N_{sg} = \left(\frac{u_t}{u_o}\right)$		Flow pattern: N_{Re}# N_{Ma} N_{Kn}
Electrostatic precipitation	Electric field gradient ‡ a) attraction	$N_{sec} = \left(\frac{k_m Q_p \epsilon_b}{\mu D_p u_o}\right)$	δ_p, δ_b *	Surface accommodation:
	b) induction	$N_{sei} = \left(\frac{\delta_p - 1}{\delta_p + 2}\right)\left(\frac{k_m D_p^2 \delta_o \epsilon_b^2}{\mu D_b u_o}\right)$		
Thermal precipitation	Temperature gradient	$N_{st} = \left(\frac{T - T_b}{T}\right)\left(\frac{\mu}{k_m \rho D_b u_o}\right)\left(\frac{k_t}{2k_t + k_{tp}}\right)$	(T_b/T), (T_p/T),* (N_{Pr}), (k_{tp}/k_t), (k_{tb}/k_t),* (c_{hp}/c_h), (c_{hb}/c_h) *	

* Not likely to be significant contributors.

† This has also commonly been termed "direct interception" and in conventional analysis would constitute a physical boundary condition imposed upon particle path induced by action of other forces. By itself it reflects deposition that might result with a hypothetical particle having finite size but no mass or elasticity.

‡ In cases where the body charge distribution is fixed and known, ϵ_b may be replaced with Q_{bs}/δ_o.

** This parameter is an alternate to N_{sf}, N_{si}, or N_{sd} and is useful as a measure of the interactive effect of one of these on the other two. It is comparable to the Schmidt number.

When applied to the inertial deposition mechanism, a convenient alternate is $(k_m\rho_p/18\rho = N_{si}/N_{sf}^2 N_{Re})$.

respective ratios of salient dimensions to some characteristic dimension or by such terms as fractional solidity in the case of filters or fractional free area in perforated plates or screens.

Fluid Flow Pattern: The basic mechanistic parameter incorporates a gross allowance for flow velocities, but it does not allow for velocity distribution in the equipment. Such distribution effects may have a marked effect. Flow distribution is determined not only by equipment geometry but also by the characteristics of the gas. For incompressible flow conditions (flow of liquids or gases at moderate to low velocities), flow patterns are measurable in terms of Reynolds number for a given equipment geometry. Where gas compressibility becomes significant, the additional allowance may be incorporated through the Mach number. Slip or molecular flow effects are measured in terms of the Knudsen number.

Particle-surface Accommodation: It is generally assumed, but not necessarily valid, that a particle will adhere once it contacts a surface. This is probably true for solids contacting solid surfaces at low contact velocities and possibly true for all liquid particles contacting liquid or solid surfaces. It is known, however, that at higher contact velocities solid particles do not all adhere to solid surfaces. In a recent study it was concluded that at high filter velocities only 10% of colliding crystalline particles adhered to the filter medium. With large particles, adhesion must be slight relative to removal forces; otherwise pneumatic conveying would be impossible. This raises the probability that in some cases the deposition phenomenon should include an "accommodation" coefficient which is in turn dependent on the physicochemical properties of both the particle and the surface.

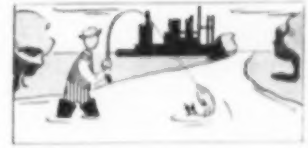
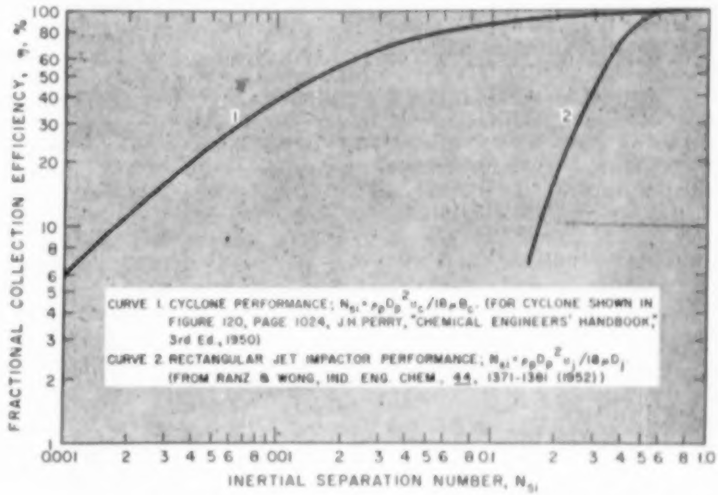


Fig. 2. Performance of inertial separation devices.



In any collection equipment, all the above-mentioned factors are operative simultaneously and a general description of deposition efficiency would require a functional relationship in terms of the various basic mechanistic parameters, their specific modifying parameters, and the various system parameters. Thus, the general case is exceedingly complex. In actual applications, however, only one or a few mechanisms are outstanding or controlling, and the performance can be closely approximated by reduction to the specific controlling factors. Reference can be made to the field of fluids handling for an analogous situation. Here, also, the general case is complex, involving effects of turbulence, roughness, hydraulic jump, slip flow, compressibility, etc. Yet most applications reduce themselves to one or two simple mechanisms. As in the fluids-handling case, however, the simplification in dust collection is possible only with a more or less restricted range of operating conditions. As operating conditions change, the controlling mechanism may change. Thus, the general mechanisms should be kept in mind in order to recognize the cases where this may occur. For example, with filters operated at high velocity, the controlling mechanism is usually inertial deposition. For operation at low velocities, however, it is probably diffusional. Filter performance characteristics are entirely different for these extreme velocity ranges.

The trade literature presents so-called fractional efficiency curves for cyclones which are simply plots of collection efficiency against particle size. Despite some claims to the contrary, these are applicable only for a cyclone of given geometry, given size, and given operating conditions. Since cyclones usually operate primarily by the inertial mechanism, such plots can be generalized by presenting them as plots of collection efficiency against the inertial separation number. This is essentially the equivalent of the method of presentation given in Perry's Handbook (*12*) where collection efficiency is shown as a function of the ratio of particle size to a so-called cut size. The term N_{si} is related to the cut size ratio by

$$N_{si} = \left(\frac{1}{4\pi n_t}\right)\left(\frac{D_p}{D_{pc}}\right)^2 \qquad (1)$$

Figure 2 shows the performance data (*12*) replotted in this fashion.

A fractional efficiency curve generalized in this fashion should be applicable to any size cyclone of the given geometric proportion and to any operating conditions, insofar as deposition is concerned. In such a generalization various other factors, such as Reynolds number effects, are assumed to be negligible, as is usually the case with cyclones larger than 6 in. diam. at normal operating conditions. For units of smaller diameter, however, a Reynolds number effect may be significant. It should be noted here that for curvilinear flow the so-called critical or transitional Reynolds number range is considerably higher than for flow in straight pipes.

For comparative purposes, Figure 2 also shows the performance data given by Ranz and Wong (*13*) for rectangular jet impactors used for particle size analysis. As a first approximation, such jets may be looked upon as ¼-turn cyclones. It is interesting to note that the inertial separation numbers corresponding to 50% separation for the cyclone and the jet impactor differ by a factor of approximately 20, which is also the ratio of the so-called "number of turns" in the cyclone to that in the jet. This close agreement is actually circumstantial since the mechanism is considerably more complex than visualized by a simple number-of-turns concept. It does illustrate, however, the order-of-magnitude agreement between entirely different concepts or approaches.

2. Conditioning

Deposition mechanisms for given particulate and equipment systems have been considered above, but the actual deposition efficiency that may

be attained in a given application may be modified by proper conditioning of the particles or of the collecting surface. Sonic flocculation, for example, is not a deposition mechanism in a practical sense. It is, instead, a means whereby small particles are built up to effectively larger particles that are more readily deposited by the action of one of the mechanisms discussed above.

If the particles suspended in a gas stream to be cleaned are originally in a flocculated state, passing the gas through a duct at high velocity may deflocculate them, making them more difficult to collect. Thus, a cyclone, which should theoretically give a higher collection efficiency at higher gas rates, may actually show a reverse trend when dealing with flocculated dusts. In this case the cyclone itself is acting as a conditioning agent by deflocculating particles during the collection process. In such cases, it is not that the basic deposition mechanisms are any different, but that another process that reduces the effective size of the suspended particles is superimposed on the deposition process.

Conditioning may take the form of condensing moisture on suspended particles in order to increase their size and make them more readily separable from the gas stream. This is feasible only with relatively low concentrations of fine particles.

The question of surface accommodation just discussed also raises the possibility of treating either particles or collection surfaces to increase mutual adhesion. In viscous-coated air filters, for example, the fibers are coated with an oil, supposedly to prevent reentrainment of deposited dust. In the light of recent results, however, it is possible that such a coating may actually serve an additional role in providing for enhanced initial adhesion of particles to the surface during the deposition process.

In the case of mists, passage of the mist-laden gas through a packing at high velocity may result in coalescing the mist particles into large droplets which are then readily collectable in a simple apparatus. The process involves a deposition of fine mist particles on the packing elements, with a subsequent reentrainment by the gas stream of deposited liquid in the form of coarser drops. The packing, while itself a collecting device, is actually acting as a conditioning agent for subsequent collection devices. Another example in this category is the flocculation of carbon black particles in electrostatic precipitators for subsequent collection in cyclones.

B. SURFACE RETENTION

The fact that particles are deposited on a surface is no assurance that they are collected. To be collected, they must remain on the surface, at least statistically. As in the case of the mist agglomerator just discussed, it is possible to have 100% deposition efficiency with 0% collection efficiency.

The problem of retaining a deposit on a surface is basically one of having sufficiently high surface forces to counteract the dislodging tendencies of the fluid shear as it passes over the deposit. Heavy deposits in a filter may be dislodged more readily than light deposits. The attractive surface force on a thin deposit should be essentially the same as for a thick deposit, but the shearing force may increase with the thickness of the deposit. Thus, thick or heavy deposits in filters are more susceptible to dislodgement than thin or light ones. This poses the potential of conditioning either particle or surface to increase deposit retention characteristics. In electrical precipitators, the gradual accumulation of a low conductivity dust on the collecting electrodes results in a potential gradient build-up across the dust deposit. This results either in a reduced electrostatic field strength across the gas stream or in a disruptive discharge across the deposit which dislodges it. It is to raise the conductivity of the deposit that so-called conditioning is resorted to in operation of electrical precipitators.

C. DEPOSIT REMOVAL

In any continuous collection equipment, some means must be provided for removing the accumulated deposit either periodically or continuously. In the case of bag filters it is this phase, rather than that of normal collection efficiency, that constitutes the primary engineering design consideration. Although deposit removal usually is purely a problem of mechanical design, it must be considered in terms of over-all collection efficiency. For example, in cyclone collectors, it is common to discharge collected dust through an outlet connected to a screw conveyor, a rotary lock, or simply a flapper valve. Depending on the pressure in the cyclone and the air-tightness of the valve, cyclone collection efficiency can be markedly affected by relatively minute in-leakage of air at the dust discharge hopper.

CURRENT KNOWLEDGE

As will be noted from the above, the basic understanding of the mechanisms by which collection equipment functions has been established, with the exception of the nature and magnitude of phenomena involving forces between particles or between particles and surfaces. There are, however, many fundamental areas where more detailed quantitative information is required. It is only in recent years that any significant use has been made of classical hydrodynamics to arrive at over-all theoretical solutions for depositions on simple geometric bodies. The flow pattern in actual collection equipment is usually too complex to permit such direct solutions. However, the idealized solutions for simple systems are exceedingly useful as a guide in predicting the nature and order of magnitude of trends to be expected in actual equipment.

Deep-bed filters represent an excellent example of cases in which classical hydrodynamics has been successfully used to arrive at rational equipment design bases, which are probably more reliable than the ability to assess the basic conditions of any applied problem. Available data on the performance of deep-bed filters have essentially confirmed theoretical predictions regarding liquid or tacky aerosol particles or solid aerosol particles at low filtration velocities *(4, 5, 10)*. At high filtration velocities, however, surface adhesive forces play a major superimposed role. The lack of knowledge of this phase is still a major deterrent to quantitative rationalization of collection of solid aerosols in high velocity filters. It is also a major obstacle in quantitative prediction of filter life, where the density of aerosol deposit is governed to a large extent by the equilibrium between surface forces and fluid shear forces.

Although a theoretical solution is highly desirable, it is not essential to an engineering rationalization of the characteristics of collection equipment, and the available theoretical knowledge is adequate to arrive at more rational solutions than have been achieved. Most available equipment investigations have been either highly superficial or restricted to such a specific application that no valid generalization of the results has been possible. From the standpoint of engineering more economic collection equipment installations, reliable information of the following types is sorely needed:

1. establishment of the controlling performance mechanisms and limitations thereof for the various common types of collection equipment

2. establishment of generalized quantitative engineering performance data for the various common types of collection equipment

3. establishment of optimum economic design proportions and operating conditions for the various common types of collection equipment.

Attainment of these objectives does not imply assembly of performance data on a wide variety of proprietary equipment. Instead it calls for a critical quantitative evaluation of actual or simulated representative devices to establish important or critical performance trends over all potential operating conditions. Such data may not be quantitatively applicable to any specific proprietary equipment, but they should lead to a basis for criteria by which such equipment may be assessed in any and all applications.

Measurement Techniques

Any basic evaluation of equipment performance, as well as any evaluation of actual field conditions, is beset with a number of measurement problems, some of which are commonly recognized and some of which are not. Particle size is probably the single most important factor in determining how a specific piece of equipment will perform. The most salient measurement problems are associated with the techniques for determining particle size.

PARTICLE FLOCCULATION

Particulates in gas suspension are flocculated to a greater or lesser extent depending on the material, the concentration, the general size range, and the prior treatment. Flocculation becomes most pronounced with high concentrations of particulates smaller than 10μ diam. The performance of the collection equipment is dependent on the effective size distribution of the suspended particles and substantially independent of the ultimate or dispersed size distribution. Methods of particle size analysis commonly used attempt to measure not the effective size of the particles as they exist in the air stream but the ultimate or dispersed size distribution since this is the only reproducible state. Thus, with the many pitfalls normally involved in conventional methods of size analysis, this added question may thoroughly confuse the application to equipment performance. To make matters worse, state of flocculation is not a fixed quantity in a given operation; it may well be influenced by the operating conditions of the equipment itself. This is probably the single major reason for the many conflicting results reported in the dust and mist collection literature to date. To avoid this dilemma, it is necessary, therefore, to develop a means for measuring the effective size distribution of the particles as they exist in the gas stream.

The aerosol camera (*2*), a device capable of photographing aerosol particles *in situ*, was one of the first attempts in this direction. In principle it is an ideal solution to the problem. The aerosol camera has, however, the following disadvantages:

1. It has not yet been developed for use with particles smaller than 2μ.

2. It involves relatively laborious counting procedures.

3. In most cases, to arrive at an effective size from the standpoint of equipment performance, a separate measurement of particle density is required—an experimentally difficult task in itself.

In recent years a continuous version of a gravity settling chamber has been successfully used in a number of applications to measure the effective inertial particle size distribution. In this device, a particle-laden gas stream is passed through a long, shallow settling chamber at a controlled rate and under streamline flow conditions. The size distribution is calculated directly from a measurement of the deposit gradient in the chamber. This chamber is restricted in its application to measuring effective size distribution in the range of 1 to 50μ diam. under laboratory conditions and probably 3 to 50μ under field conditions. The upper limit is set by inability reasonably to obtain streamline flow for analyses at larger sizes; the lower limit is set by the predominant effects of convection currents and by excessive gas retention times. A centrifugal adaptation of this device has been designed but not evaluated. This should permit application to effective particle sizes in the range of 0.01 to 10μ diam.

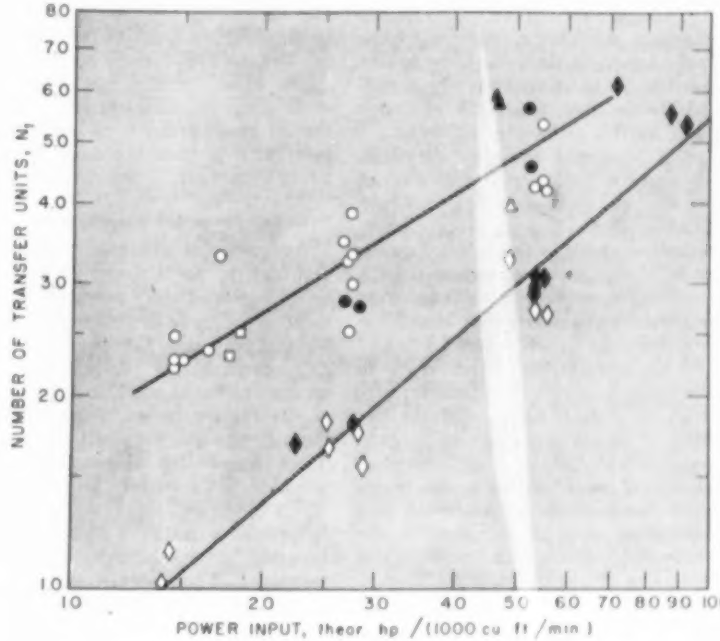
Optical methods offer a potential means for measuring effective size distribution without altering the size distribution. They have, however, not been developed to the point where they may be applied reliably to the size range, particle shapes, and particulate concentrations involved in industrial dust collection applications.

AEROSOL GENERATION

For many years there has been a general search for so-called "standard" test dusts which can be used to obtain a relative measure of equipment performance. Such dusts can give only relative results and cannot be used to obtain any but crude indications of the way in which particle size may influence equipment performance. Considering the flocculation factor discussed above, even the relative results may prove misleading.

To obtain a better representation of the effect of particle size on equipment performance, the trade has resorted in some instances to so-called fractional efficiency curves. These are calculated

Fig. 3. Performance data for salt-cake fume scrubbers (15).



usually from a comparison of the size analysis of the material fed to the equipment (or collected in the equipment) and that escaping collection. Results of this calculation are sensitive to the accuracy of the respective size analyses. When one considers the inherent limitations of the size analysis methods used and the superimposed effects of flocculation, one must have implicit faith in his own ability to fair the data in order to arrive at a reasonably reliable fractional efficiency curve by this procedure.

The fractional efficiency curve is, however, a basically sound way of presenting performance data. It is only because of the limitations of current techniques, both in the original evaluation of the curve as well as in the application to field conditions, that this performance criterion has fallen into disrepute in some areas.

A far more reliable procedure is to use uniform or relatively uniform particles in obtaining the necessary test data. The particles in such suspensions should also be essentially completely dispersed. There are essentially two methods for achieving such particulate suspensions. One is the controlled vaporization - condensation technique originally proposed by Sinclair and LaMer (*16*). This is capable of producing low concentrations of uniform particles in the size range smaller than 5μ.

Pneumatic atomization of solutions is another method by which relatively uniform particle suspensions can be generated. Although this technique does not yield entirely uniform particles, the uniformity is sufficiently good for many purposes. This technique is useful for producing particles in the size range of 50 to 0.1μ, and possibly finer. Size control is also simpler in this technique than in the vaporization-condensation process.

Aerosols generated by the vaporization-condensation technique have been successfully used in evaluation of filter performance characteristics. However, neither it nor the pneumatic atomization technique appears to have been employed to any significant extent in basic studies of the performance characteristics of other types of collection equipment. Both methods warrant further consideration and utilization for this purpose.

In other fields, the liquid analog has been successfully used to solve gas phase problems in cases in which direct evaluation with the gas phase presented problems that could be circumvented by using the liquid phase. Use of liquids for evaluating performance characteristics of collection equipment would circumvent the particle size problems because liquid systems would call for dealing with a larger particle size range. Since particulate suspensions in liquids can be stabilized whereas suspensions in gases cannot, the entire problem of flocculation can be avoided with liquids. Liquid systems will, however, introduce other problems which must be carefully analyzed before considering specific applications for this technique. This technique is worthy of more detailed consideration. It has shown great promise in applications to cyclone performance made at Ohio State University.

Potential Areas for Development

A number of attractive avenues of approach to development of substantially improved dust collection equipment can already be recognized today. Several years ago, Lapple and Kamack (*9*) compared the performance of a number of liquid scrubbing devices of widely varying design, using the same dust dispersions for each equipment. They found that the design of a scrubber had relatively little influence on its collection efficiency and that the latter was primarily a function of the pressure drop through the entire scrubber. They also suggested the possibility that the dominant factor in determining the efficiency of a scrubber was the total power expended regardless of whether the power was introduced in the gas phase in terms of gas pressure drop, in the liquid phase in terms of liquid flow rate and pressure required for hydraulic atomization, or by mechanical means. Subsequent work has indicated that this suggestion of a relation between total power expended and efficiency was essentially correct. In the authors' experience there have been only two situations in which a significant deviation from this relation has appeared to occur in the direction of improved collection efficiency for a given power consumption. The first situation was with a particular design of liquid-gas contacting device, and the second occurred when the scrubber was operated under condensing conditions. The relative performances of scrubbers operating under condensing and noncondensing conditions are illustrated in Figure 3. Data are plotted in terms of total power introduced into the scrubber vs. the number of transfer units obtained. The transfer units are a measure of efficiency and more clearly indicate the true increment of performance than efficiency itself. These data were obtained with several types of scrubbers operating on salt cake fume from a kraft paper mill recovery furnace and are treated in more detail by Semrau (*15*). Both curves represent conditions in which the stack gases were at a temperature of about 300° F. and contained a relatively large amount of water vapor. The lower curve represents conditions where the stack gases were contacted with scrubbing liquor at the adiabatic saturation temperature of approximately 150° F. These are the normal conditions under which scrubbers are operated on kraft mill recovery furnaces. The upper curve, however, represents conditions in which the moist stack gases were contacted by a scrubbing liquor consisting of fresh water at a temperature of 70° F. or less. As may be noted, for the same number of transfer units, or efficiency, the contact with cold water reduced the power requirement for the scrubber to as little as one-third that required when operating with a hot scrubbing liquor. Such a reduction in power requirement for the large volume of stack gases involved would be of major economic importance.

Both the concept and usage of condensation as a means of industrial dust collection are quite old. In recent years work has been carried out in which condensation for this purpose was achieved by adiabatic expansion through a nozzle or by injection of steam. The method described above, however, is older, having been used in the Harz Mountains of Germany at a silver smelter in 1909 (*17*).

It should be noted that there was considerable scatter in the data represented by the curves in Figure 3, and that the improvements obtained could only be detected on the basis of a large number of points. Undoubtedly much of this scatter results from variations in effective size distribution of the dust generated in the furnace from time to time. Also, it may well be that the specific conditions under which condensation is carried out have a major influence on the effectiveness of the condensation. In any event, a systematic investigation of the process, utilizing dusts of a controlled particle size and with adequate methods of measurement of particle size, may well reveal conditions under which substantially better performance than that indicated can be obtained.

Equally attractive opportunities exist in other methods of dust collection. For example, it is known that in bag filters the fabric itself can exert a marked influence on the resistance coefficient of the dust cake. Adequate knowledge of the factors responsible for this phenomenon might permit substantial reductions in the cloth area required for bag filters.

Deep-bed fibrous filters have in re-

cent years become widely used for situations involving light dust loading, such as in air conditioning. They can operate with high efficiencies on even fine aerosols and their first cost is attractively low. They have not, however, found particular use for industrial problems where the higher dust loading results in prohibitively short filter life. Development of practical means of cleaning these filters might well, however, introduce an economic means of treating industrial waste gases containing fine aerosols. It is even possible that these filters could be used as inexpensive flocculators by operating on a continuous basis. This might be accomplished by designing them so that accumulated dust deposits would shear off in a flocculated state for subsequent collection by cyclones or low pressure drop scrubbers.

Inertial devices such as cyclones are limited in the particle sizes which they can effectively collect by the particle accelerations which can be produced and by the restraining wall friction. Many attempts have been made to increase these accelerations by mechanically driven members, but the potentialities of this method would warrant considerably more attention. Such driven units have great potential for radical reduction of equipment size, weight, and cost when dealing with submicron materials, factors which are of especial interest in aircraft applications.

The dust escaping from electrostatic precipitators is generally flocculated to some degree, and in some instances the escaping dust resembles a snowfall. These snowing conditions tend to offset the advantages gained in reduced emission by the use of the precipitator since the settling rate of these large flocs may considerably exceed that of the original dust dispersion. These flocs presumably occur as a result of the shearing of deposits off the electrodes. Where this problem is serious, it might be well to design the precipitator primarily as a flocculator, to reduce the size—and therefore the cost—of the precipitator, as has been done in carbon black collection applications. Much more needs to be known, however, as to the mechanics of surface retention and deposit removal before optimum constructions can be accomplished and systems designed with confidence.

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Notation

Any consistent system of units may be used; the absolute metric (c.g.s.) system is shown by way of illustration.

B_c = cyclone inlet width, cm.
c_k = specific heat of gas, (cal.)/(° C.)(g.)
c_{kb} = specific heat of collecting body, (cal.)/(° C)(g.)
c_{kp} = specific heat of particle, (cal.)/(° C.)(g.)
D_b = characteristic dimension of collecting body or device, cm.
D_{b1}, D_{b2} = other characteristic dimensions of collecting body or device, cm.
D_j = slot width for rectangular jet impactor, cm.
D_p = characteristic particle diameter or dimension, cm.
D_{pc} = particle cut size, cm.
D_v = diffusion coefficient for particle, sq.cm./sec.
k_m = Stokes-Cunningham correction factor, dimensionless
k_t = thermal conductivity of gas, (cal.)/(sec.)(sq.cm.)(° C./cm.)
k_{tb} = thermal conductivity of collecting body, (cal.)/(sec.)(sq.cm.)(° C./cm.)
k_{tp} = thermal conductivity of particle, (cal.)/(sec.)(sq.cm.)(° C./cm.)
n_e = equivalent number of turns made by gas stream in cyclone, dimensionless
N_{Kn} = Knudsen number, = (λ/D_b), dimensionless
N_{Ma} = Mach number, dimensionless
N_{Pr} = Prandtl number = $(c_k\mu/k_t)$, dimensionless
N_{Re} = Reynolds number = $(D_b u_o \rho/\mu)$, dimensionless
N_{sc} = interaction number = 18 $\mu/k_m \rho_p D_p$), dimensionless
N_{sd} = diffusional separation number, dimensionless
N_{sec} = electrostatic-attraction separation number, dimensionless
N_{sei} = electrostatic-induction separation number, dimensionless
N_{sf} = flow-line separation number, dimensionless
N_{sg} = gravitational separation number, dimensionless
N_{si} = inertial separation number, dimensionless
N_{st} = thermal separation number, dimensionless
N_t = number of transfer units = ln $[1/(1-\eta)]$, dimensionless
Q_{bs} = electrical charge surface-concentration, coulombs/sq.cm.
Q_p = electrical charge on particle, coulombs
T = characteristic temperature of gas, ° C. abs.
T_b = characteristic temperature of collecting body, ° C. abs.
T_p = characteristic temperature of particle, ° C. abs.
u_c = cyclone inlet velocity, cm./sec.
u_j = jet velocity, cm./sec.
u_o = characteristic velocity of gas in equipment, cm./sec.
u_t = free settling velocity of particle under action of gravity, cm./sec.
μ = gas viscosity, poise
ρ = gas density, g./cc.
ρ_p = particle density, g./cc.
δ_o = permittivity of free space, (coulombs)^2/(dyne)(sq.cm.)
δ_b = dielectric constant of body, dimensionless
δ_p = dielectric constant of particle, dimensionless
ϵ_b = characteristic potential gradient at collecting surface, v./cm. or (dynes/coulomb)
λ = mean free path of gas molecules, cm.
ϵ_v = fractional volumetric solidity (for granular or fibrous beds), dimensionless
α = fractional free area (for screens, perforated plates, grids), dimensionless
η = fractional collection efficiency, dimensionless

STATISTICAL ANALYSIS in a POLYMERIZATION PROCESS

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A process study carried out in the manufacturing plant differs from a laboratory or pilot plant experiment. In an investigation of the polymerization process described in this paper the criteria used to decide upon the variables to be investigated were different from those the laboratory scientist would select.

There are several criteria that the manufacturing engineer can employ to help him decide on the variables to be studied in a plant. One is whether the variable can be controlled without major changes in plant operating equipment. As an example, in the experiment described here it was known that polymerization temperature variation would affect the product, but costly changes in plant operating equipment would have been needed to control the temperature better. This variable was relegated to the laboratory for investigation.

The plant experiment should take place with the minimum curtailment of production schedules. Those variables which might affect product quality severely enough to cause the production of a large amount of out-of-specification product should be examined in the laboratory. The cost of plant scale experimentation heightens the need for efficient experimental design, with the fewest experiments being run to gain the desired information.

Process Description

The polymerization process (Figure 2) uses a fluorocarbon monomer as a starting material. This freshly made monomer is mixed with recycle monomer from the polymerization section and purified and this purified monomer is stored and used as the manufacturing process requires.

Monomer and catalyst are charged to the reaction vessels and the polymerization is allowed to proceed. Unreacted or recycle monomer is recovered and the polymer product is transferred from the reaction vessel to

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Fig. 2.

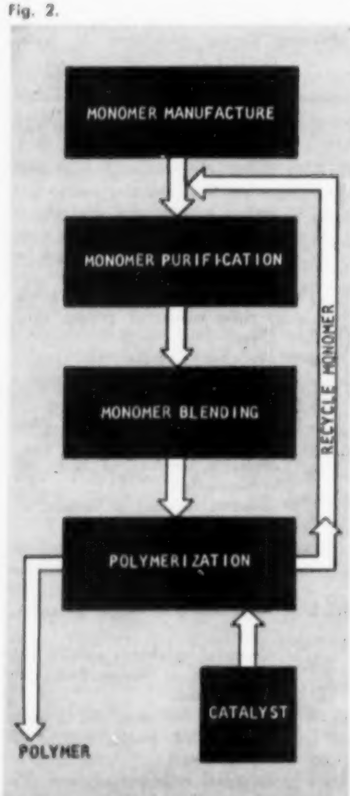

Table 1.—Results

Catalyst concentration		Blend ratio 1 Conversion	Blend ratio 1 ZST	Blend ratio 2 Conversion	Blend ratio 2 ZST
		—4.2	—15	1.7	2
		0.5	2	—3.6	—8
		—2.3	1	0.4	8
1		—2.4	—6	0.7	—4
		—0.9	1	—0.9	—2
		—1.1	—2	—3.3	—11
		—1.1	1	3.2	0
	ΣX	—11.5	—18	—1.8	—15
	ΣX^2	32.17	272	38.44	273
		—0.9	0	—0.7	—4
		0.4	0	—0.7	0
		0.0	1	—0.3	—2
2		0.3	6	0.4	—1
		—2.9	—4	0.3	—3
		1.1	2	1.7	2
		2.1	3	—0.1	—7
	ΣX	—0.1	8	0.6	—15
	ΣX^2	15.09	66	4.22	83
		1.4	7	0.1	2
		0.7	1	0.6	0
		1.6	6	—2.3	6
3		2.7	6	1.6	—2
		1.2	0	3.2	—1
		1.3	3	—3.5	—9
		0.3	—2	3.9	10
	ΣX	9.2	21	3.6	6
	ΣX^2	15.2	135	45.92	226

dryers. The dried polymer is weighed, sampled, and evaluated. The recycle monomer caries with it certain by-products of the process, some of which may be contaminants. The recycle monomer is purified for reuse.

Experiment

The experiment was designed to answer the question whether the ratio of fresh to recycle monomer in monomer blends affected the polymerization conversion or any of the product qualities. The blend ratios used in the experiment were at the extremes of probable plant operating conditions.

The second factor the effect of which was investigated was the level of catalyst concentration in the monomer at the start of polymerization. Variations in the catalyst concentration over a broad range do affect the conversion and the molecular weight of the product. Since the product molecular weight specifications are narrow, the catalyst concentration variation was held within a small range. The plant operating concentration was placed at the center point and the experimental catalyst concentrations were placed on both sides of the standard level. The effects of this variable as well as the other one studied were measured by two responses: (1) conversion and (2) ZST, a measure of the apparent molecular weight of the polymer.

Because of the relatively narrow range over which one can usually manipulate the independent variables, the magnitude of the responses may be small. It is, therefore, necessary to replicate or repeat the experiment. If an estimate of the process variance is available from previous data, then the number of replications needed for a given confidence in the conclusions can be calculated.

Seven polymerizations were run at

Table A.

Blend Ratio	Catalyst Concentration		
	1	2	3
1	7	7	7
2	7	7	7

Table 2.—Analysis of Variance of Conversion Data

Blend Ratio	Catalyst Concentration 1	2	3	Row totals
1	−11.5	−0.1	9.2	−2.4
2	−1.8	0.6	3.6	2.4
Column totals	−13.3	0.5	12.8	0.0

$$\text{Correction term} = \frac{(\Sigma X_i)^2}{N} = \frac{(0)^2}{42} = 0$$

$$\text{Total sum of squares} = \Sigma X_i^2 - \text{C.T.} = 151.36$$

$$\text{Sum of squares for blend ratio} = \frac{(-2.4)^2 + (2.4)^2}{21} = 0.55$$

$$\text{Sum of squares for catalyst concentration} = \frac{(-13.3)^2 + (0.5)^2 + (12.8)^2}{14} = 24.36$$

Sum of square for catalyst concentration X blend ratio interaction

$$= \frac{(-11.5)^2 + (-0.1)^2 + (9.2)^2 + (-1.8)^2 + (0.6)^2 + (3.6)^2}{7} - (0.55 + 24.36) = 8.44$$

The two degrees of freedom asociated with catalyst concentration have been partitioned (5) as follows:

A. For linear term

Linear coefficients	Column totals	Products of coefficients and column totals
1	−13.3	−13.3
0	0.5	0.0
−1	12.8	−12.8
		−26.1

$$\text{Mean square for linear term} = \frac{(-26.1)^2}{14[(1)^2 + (-1)^2]} = 24.33$$

B. For quadratic term

Quadratic coefficients	Column totals	Products of coefficients and column totals
−1	−13.3	13.3
2	1.0	1.0
−1	12.8	−12.8
		1.5

$$\text{Mean square for quadratic term} = \frac{(1.5)^2}{14[(-1)^2 + (2)^2 + (-1)^2]} = 0.03$$

Source of variation	Degrees of freedom	Sum of squares	Mean square	F	$F_{.05}$
Blend ratio	1	.55	.55	.16	4.1
Catalyst concentration					
Linear term	1	24.33	24.33	7.01	4.1
Quadratic term	1	.03	.03	.01	4.1
Interaction	2	8.44	4.22	1.22	3.2
Error	34	118.01	3.47		
Total	39	151.36			

$$\text{Slope of conversion line} = \frac{1}{(14)(2)}[12.8 - (-13.3)] = 0.93 \frac{\text{units}}{\text{catalyst increment}}$$

$$\hat{\sigma}_{slope} = \left[\frac{3.47}{28}\right]^{1/2} = 0.352$$

$$95\% \text{ confidence range of slope} = \pm\hat{\sigma}_{slope} \times t_{1,.05,.05} = \pm(.352)(2.03) = \pm 0.72$$

95% confidence interval: 0.21 to 1.65

Table 3.—Analysis of Variance of ZST Data

Blend ratio	Catalyst Concentration 1	2	3	Row totals
1	−18	8	21	11
2	−15	−15	6	−24
Column totals	−33	− 7	27	−13

$$\text{Correction term} = \frac{(\Sigma X_i)^2}{N} = \frac{(-13)^2}{42} = 4.02$$

$$\text{Total sum of squares} = \Sigma X_i^2 - \text{C.T.} = 1{,}055 - 4.02 = 1{,}050.98$$

$$\text{Sum of squares for blend ratio} = \frac{(11)^2 + (-24)^2}{21} - 4.02 = 29.17$$

$$\text{Sum of squares for catalyst concentration} = \frac{(-33)^2 + (-7)^2 + (27)^2}{14} - 4.02 = 129.33$$

Sum of squares for catalyst concentration X blend ratio interaction

$$= \frac{(-18)^2 + (8)^2 + (21)^2 + (-15)^2 + (6)^2}{7} - (29.17 + 129.33 + 4.02) = 25.33$$

The two degrees of freedom associated with catalyst concentration have been partitioned (5) as follows:

A. For linear term

Linear coefficients	Column totals	Products of coefficients and column totals
1	−33	−33
0	− 7	0
−1	27	−27
		−60

$$\text{Mean square for linear term} = \frac{(-60)^2}{14[(1)^2 + (-1)^2]} = 128.57$$

B. For quadratic term

Quadratic coefficients	Column totals	Products of coefficients and column totals
−1	−33	33
2	− 7	−14
−1	27	−27
		− 8

$$\text{Mean square for quadratic term} = \frac{(-8)^2}{14[(-1)^2 + (2)^2 + (-1)^2]} = 0.76$$

Source of variation	Degrees of freedom	Sum of squares	Mean square	F	$F_{.05}$
Blend ratio	1	29.17	29.17	1.14	4.1
Catalyst concentration					
Linear term	1	128.57	128.57	5.05	4.1
Quadratic term	1	.76	.76	0.03	4.1
Interaction	2	25.33	12.67	0.50	3.2
Error	34	867.14	25.50		
Total	39	1,050.98			

$$\text{Slope of conversion line} = \frac{10}{(14)(2)}[27 - (-33)] = 21.4 \frac{\text{units}}{\text{catalyst increment}}$$

$$\hat{\sigma}_{slope} = 10\left[\frac{25.50}{28}\right]^{1/2} = 9.64$$

$$\text{95\% confidence range of slope} = \pm\hat{\sigma}_{slope} \times t_{(.05,\ 34)} = \pm(9.54)(2.03) = \pm 19.4$$

95% confidence interval: 2.0 to 40.8

each monomer catalyst condition according to the plans as shown in Table A.

Results obtained in this experiment for conversion and ZST are presented in Table 1. From the authors' knowledge of the process, two of the original data values were judged to be spurious. For those two values that were judged out of line, the average value of the subgroup in which each occurred was substituted and the degree of freedom associated with each adjusted value was subtracted from the total degrees of freedom in the analysis of variance (*1*). By this method the residual variance is minimized and allows completion of the analysis as though the original data were balanced. An estimate of the standard deviation was obtained by computing the range of each subgroup of seven, by finding the average range, and by dividing by the appropriate d_2 factor (*2*). Estimates of standard deviation obtained were 1.3 units of conversion and 49 units of ZST. Since it is generally safe to round data to one quarter of the standard deviation (*3*), the values for ZST were rounded to the nearest 10 units. No savings in computation time would have been obtained by rounding the conversion data.

To aid further in simplifying the analysis, the data were coded by subtracting the grand average from each value. In the case of the ZST data each value also was divided by ten. Subtracting a constant from each value has no effect on the variation, but dividing individual values by a constant has the effect of dividing the estimates of variance by the constant squared. Data in Table 1 are the coded and rounded values.

Details of the analysis of variance for conversion are shown in Table 2. The numbers in the six boxes represent the algebraic total of the seven values of the particular combination of blend ratio and catalyst concentration. ΣX^2 represents the sum of the squares of each of the 42 data values. A description of the calculations for the general case in an analysis of variance of this type can be found in the literature (*1, 4, 5*).

Table 3 represents the details of the analysis of variance for ZST. The procedure used is exactly the same as that for the conversion data.

Conclusions

The effect of catalyst in the range studied is to change conversion at the rate of 0.93 ± 0.72 units per increment of catalyst concentration change, where ± 0.72 units represent the 95% confidence range. The 95% confidence interval is the length of the in-

terval which covers the true value in 95% of the cases in which it is used.

The effect of catalyst in the range studied is to change ZST 21.4 ± 19.4 units per increment of catalyst concentration change, where ± 19.4 units represent the 95% confidence range.

Figure 1 shows a plot of the data for conversion and ZST. The fact that a straight line fits the data so well is attested to by the small value for the quadratic portion of the catalyst sums of squares. In other words, the linear term accounts very well for the variation due to changing catalyst concentration.

Neither conversion nor ZST was significantly affected by monomer blend ratio.

In terms of plant operating conditions the most important conclusion is that no special care is needed to control the blend ratio of fresh-to- recycle monomer in the purified feed to the polymerization section. A second conclusion is that, in the range studied, changing catalyst concentration changes both conversion and ZST in the same direction. This means that, when advantage is taken of the increase in conversion afforded by increasing catalyst concentration, a higher ZST is to be expected.

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This article and the article following were presented at the Stevens Symposium on Statistical Methods in the Chemical Industry, Hoboken, New Jersey, sponsored by Metropolitan Section and Chemical Division of the American Society for Quality Control and Stevens Institute of Technology.

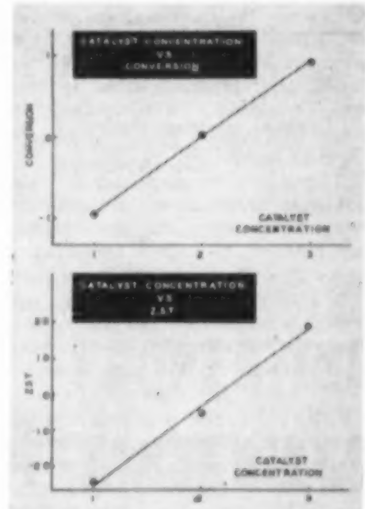

Fig. 1. Graphs of catalyst concentration vs. conversion and catalyst concentration vs. ZST.

A statistical engineer relates for *CEP* readers some interesting facts on statistical methods and quality control in a small chemical company. Attacking a problem by graphical representation, the author claims, is as important as the mathematics involved. It is his experience that plant people go along with any method which they find helpful in arriving at a solution of their problem.

STATISTICAL QUALITY CONTROL in a CHEMICAL PLANT

Harold Davidson | Metal & Thermit Corporation *

Until about five years ago quality control in Metal & Thermit Corporation was carried out in the traditional fashion. The chief chemist at each plant observed the quality of products produced day by day and called attention to anything he considered unsatisfactory. After a preliminary period of preparation and education, a company-wide quality control organization, emphasizing use of modern statistical methods, was established. The director of quality control, who is the staff adviser to the head of the manufacturing department, audits quality operations and provides technical consultation on the use of modern quality control tools.

With this operation now on a formal and routine basis, necessary reports are submitted at monthly, quarterly, and annual intervals. All products are on a control chart basis, process control charts also being used.

The program is carried out as far as possible by the local plant chemists or supervisors of quality control, the organization using liaison channels of communication.

Statistical Quality Control Tools

1. PRODUCTION CONTROL CHARTS

The production control charts are considered the keystone of quality operation. Most of the processes are batch and it has been found handiest to set up the charts showing results by batch and using the moving range method to calculate control limits. It turns out that this method is easy to understand and figure out, and it gives limits for process variables which make sense to the people who use them.

Only a few tests are applied for lack of control. A batch outside control limits, more than seven batches in succession above or below average, or any clear-cut trends or shifts in average are considered a basis for action. The process as a whole is considered in control if no more than one batch in thirty is outside limits.

The control charts give a clear picture of the situation, which is easier for both management and plant men to follow than a mere tabulation of figures would be.

Metal & Thermit Corporation is a producer of a number of specialty and premium chemicals. These include organic and inorganic tin chemicals, antimony chemicals, metals and alloys, industrial thermit, industrial coatings and finishes, and plating compounds. Operations are carried on at chemical plants at Rahway, Piscataway Township and Carteret, New Jersey, and East Chicago, Indiana.

* Mr. Davidson is now with Merck & Company, Rahway, New Jersey, as engineering statistician.

When the process is controlled, it has been found suitable on occasion to test and control by composites, which are treated in the same way as an average (the allowable control limits are tightened). If a composite is out of control, the individual components are tested. If an individual batch is also out of control, individuals are tested until process control is once more established. This means that more tests are made when there are signs of trouble.

The charts are used also to make advisable adjustments in specifications. Sometimes the specifications are found to be narrow compared to process capability. Since unrealistic specifications are demoralizing, approval is sought from the sales department to broaden the specifications. Conversely, if the sales department requires tighter specifications, accommodation can be made if process capabilities permit. Otherwise, the blending, rework, or scrapping required to meet the tighter specifications can be calculated. Management can then base its decision on the economics involved. To keep the charts up to date, the control limits are reviewed and revised once a year, or more frequently if a distinct change in processing occurs.

2. PROCESS CONTROL CHARTS

The position is taken usually that a controlled product means a controlled process and, therefore, priority is given to process control charts.

Since the importance of different process control points may change with time, these charts are introduced and discontinued at the option of the plant chemist, subject to review and consultation with the director of quality control.

3. SAMPLING AND ACCEPTANCE PROCEDURES

A. Compositing

Reduction of testing frequency by compositing is something that can be done in the chemical industry, although rarely elsewhere. In the company under discussion here, it was found possible to reduce testing this way and yet control the risk of passing off-grade material. This was discussed briefly under control charts.

B. Destructive Testing

One or two cases of destructive testing have been recorded and an attempt has been made to set up the testing program on an average outgoing quality limit basis with a variables-type test, if possible.

C. Allowance for Within-batch Variation

Such allowance is not often a problem in chemical industry but occasionally it confronts the company. In those cases a calculation is made of the number of samples required to limit the allowable error of the reported batch analysis.

D. Reduced Testing Frequency

Reduced testing frequency means testing every fifth batch, for example. This is done on analyses considered relatively unimportant. In general, preference is given to compositing.

4. STATISTICALLY DESIGNED EXPERIMENTS

These statistically designed experiments are used on process improvement studies or on the development of new processes.

A. Factorial

The factorial design, especially with fractional replication, has been used frequently. The experiment is planned after discussion between plant personnel and the statistician. Organizing the experiment into blocks to pick up changes with time or unexpected introduction of additional variables has turned out to be particularly important.

B. Sequential

Although one or two sequential tests have been set up, they have not been used. It appears that the time lag between making the test and obtaining the result interferes with the usefulness of this type of test.

C. Box Type (Optimization)

The company hopes to find the box type of experiment useful. Recently two such plans were designed, but the testing and analysis have not yet been completed.

D. T-Test Experiments

A simple comparison between two operating conditions is known as the T-test experiment.

5. CORRELATION ANALYSIS

Frequently requests are made to review past production data for any relationship between operating variables and results. The yield of useful information is low, but its potentialities cannot be ignored. On one occasion a useful relationship was discovered between raw material formulation and product purity. In another case, an unexpected relationship between raw material purity and product yield was found.

Comment

- By actual use it was found that statistical methods and statistical quality control are profitable even in a relatively small chemical company.
- Results obtained should be evaluated on their own merits regardless of the means used to obtain them. It is better to work with fairly rough and approximate mathematical models than to get too wound up in refinements.
- Team work, which means close coordination between the statistician or quality control man and operating personnel, is essential to the success of any such program.

APPENDIX

- The moving-range method consists of taking the absolute difference between the results of analysis on a batch and the batch immediately following it. The average of these absolute differences (involving about 30 batches) is multiplied by 2.66, and this figure is added to the process average to get the upper control limit, and subtracted from it to get the lower control limit.
- When manufactured material is perfect, shipped material also is perfect, whether tested or not. When manufactured material is completely defective, a testing program will reject every lot, so that no defective material is shipped. Somewhere between these two extremes, a given testing program will let through a maximum percentage of defective material. This is the average outgoing quality limit.
- Factorial designs are experimental plans which involve testing all combinations of several variables. Usually, two conditions of each variable are considered so that the total number of combinations is 2^n, where n is the number of variables studied. Fractional replication is a more economical plan; the number of experiments required can sometimes be divided by some integral power of 2 without loss of desired information.
- Mathematics of the following experimental procedure has been worked out:

1. A test is run, and a result obtained.
2. By reference to the appropriate tables, one of the three following decisions is reached:
   a. The result (in conjunction with the results of any prior tests) establishes, with a particular probability, that the experiment is an improvement over some standard.
   b. The result establishes, with a particular probability, that the experiment fails to improve over standard by as much as some given quantity.
   c. No conclusion can yet be reached, and at least one more test is required.

This type of procedure is called a sequential test.

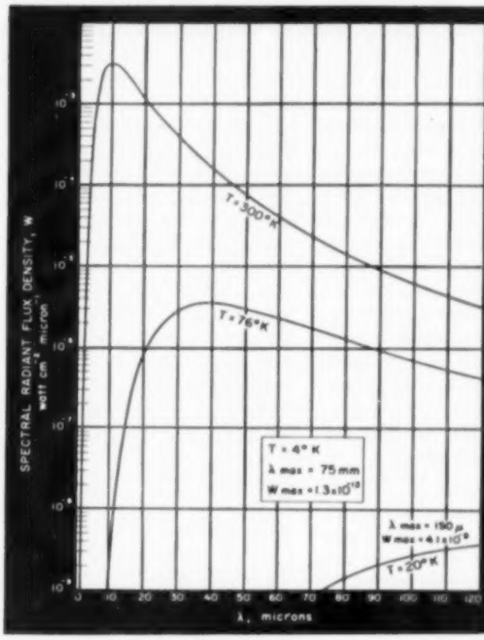

Fig. 7. Spectral energy distribution curves for black bodies at cryogenic temperatures. (W is the power radiated hemispherically from an area of 1 sq. cm. in a wavelength interval of 1 micron. 76, 20, and 4° K. are approximately the normal boiling points of nitrogen, hydrogen, and helium. Coordinates of the maximum at 4° are shown in the box, the curve for 4° K. being far below the range of this plot.)

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PROPERTIES OF MATERIALS AT LOW TEMPERATURES

(PART 3)

(Conclusion)

Thermal Insulations

The flow of heat through insulation usually involves simultaneously two or more of the basic mechanisms, radiation, gaseous conduction, and solid conduction. Where radiation is significant the properties of the boundary surfaces are important. Also the insulating medium may be inhomogeneous, as in porous solids. Consequently the overall heat transfer is a property of the *system*, not merely of the *material* of which the insulating medium is composed. In this section attention is concentrated on the physical properties that determine the effectiveness of an insulating system. The principal classes of insulations are (1) high-vacuum reflective insulation (Dewars), and (2) porous media (foams, fibers, powders).

HIGH-VACUUM INSULATION

This type of insulation, typified by the Dewar vessel, consists of an evacuated space between good-reflecting surfaces. The heat transfer is usually predominantly by radiation, but there may be significant conduction by residual gas. The radiation emitted by each surface is proportional to its emissivity, while the absorption by each surface of radiation originating at the other is proportional to its absorptivity for radiation having an energy-wavelength distribution characteristic of the other surface and its temperature. In cryogenic applications the two surfaces are usually at widely different temperatures, and since the emission of radiation varies ideally as T^4, the emission from the colder surface will usually be quite negligible. Thus, the net exchange of radiation will depend on the emissivity of the warmer surface and the absorptivity of the colder surface for the radiation emitted by the warm surface. In practice, the terms emissivity and absorptivity are used interchangeably and for brevity the same will be done hereafter.

Figure 7 shows the distribution by wavelength of the radiant energy from black bodies at some selected cryogenic temperatures. It will be noted that the preponderance of the energy is in the infrared. Strictly speaking the emissivities and absorptivities that have been discussed here should have been prefixed "total" to indicate that each is an average of spectral emissivities (i.e., those applying to a given wavelength only) weighted according to the spectral energy distribution of the radiation involved. Fortunately, metals have fairly constant spectral emissivities in the infrared, and as a result their total emissivities are approximately the same as the spectral emissivities and are approximately constant for radiation characteristic of any temperature at or below ambient. It is this characteristic that permits the use of the terms "absorptivity" and "emissivity" interchangeably for a given surface.

In addition to the distinction between spectral and total emissivities there is a further subdivision into those measured at normal incidence and those averaged over all angles between normal and grazing incidence. In heat transfer between extended surfaces it is the latter or "hemispherical" emissivities that are applicable. However, the difference between the two kinds can be at most a factor of one third *(29)* for clean surfaces and is usually ignored in engineering calculations because of the large uncertainties that can exist due to surface contaminations, the presence of complicated shape factors, etc. Unfortunately, the difference is greatest for the case of greatest practical interest, namely, where the emissivity is small.

Hemispherical emissivities of a variety of surfaces at 76-77° K. for radiation characteristic of room temperature have been determined by Fulk and Reynolds *(30)* and Zimmermann *(31)*. A compilation including other temperatures appears in a new handbook *(32)*. In Table 4 minimum re-

Table 4.—Selected Minimum Total Emissivities *

Surface	Temp., °K. 4	20	77	300
Copper	0.0050	....	0.008	0.018
Gold	.....	....	.01	.02
Silver	.0044	....	.008	.02
Aluminum	.011	....	.018	.03
Magnesium	.....	....	....	.07
Chromium	.....	....	.08	.08
Nickel	.....	....	.022	.04
Rhodium	.....	....	.078	....
Lead	.012	....	.036	.05
Tin	.012	....	.013	.05
Zinc	.....	....	.026	.05
Brass	.018	....	....	.035
Stainless Steel, 18-8	.....	....	.048	.08
50 Pb 50 Sn solder	.....	....	.032	....
Glass, paints, carbon	.....	....	....	>.9
Silver plate on copper	.....	.013	.017	....
Nickel plate on copper	.....	.027	.033	....

* Actually absorptivities for radiation characteristic of 300° K. Normal and hemispherical values are included indiscriminately.

Table 5.—Approximate Accommodation Coefficients

T, ° K.	He	H_2	Air
300	0.3	0.3	0.8-09
77	0.6	0.5	1
20	0.6	1	1

corded values of emissivity are given from the above sources for selected materials. Except for the last two entries, values at different temperatures are by different investigators, so the results are not necessarily mutually consistent or the lowest that might be attained.

These data and others lead to the following generalizations:

(1) The lowest values are obtained with the best electrical conductors.

(2) The emissivity decreases with decreasing temperature but is not a steep function of temperature.

(3) Alloying a metal increases its emissivity.

(4) The emissivity is increased by treatments such as mechanical polishing which result in work hardening of the surface layer of metal.

(5) The apparent emissivity of good reflectors is increased by surface contamination.

(6) Visual appearance (i.e., brightness) is not a reliable criterion of good reflectivity (low emissivity) for cryogenic applications. This is because (a) the visual test utilizes an entirely different range of wavelengths in which the emissivities do not necessarily maintain the same relative standings as in the infrared, (b) specularity of reflection is not advantageous where minimum heat transfer is the consideration, and (c) multiple scattering at surface defects with corresponding rise in the effective local emissivity is less the longer the wavelength.

Generalizations 2 to 4 are closely related to 1 inasmuch as the electrical resistivity usually increases with temperature, impurity, and strain. A theory that permits quantitatively correct calculation of absorptivities has been achieved only in recent years *(33)*. However, because of the strong influence of surface contaminants on the apparent emissivity, it will usually not be worthwhile to attempt accurate estimation of emissivities of industrial surfaces from the electrical resistivity of the bulk metal in cases where experimental emissivities are lacking. Instead, a rough guess based on tabulated values of emissivity for substances of similar electrical resistivity will be all that is justified for engineering purposes.

Good reflecting surfaces can be achieved in several ways:

(a) application of aluminum foil.

(b) chemical deposition of silver. This can be applied to nonmetals and chemically inert metals such as stainless steels. Spray techniques can be used for large surfaces.

(c) electroplating of silver or gold. The emissivity will approach the bulk emissivity of the plated metal as the plate thickness increases. For example, data on thin films of gold (32) suggest that the bulk emissivity is achieved at a thickness of the order of .001 in. However, a foil .00004 in. thick had an emissivity only about twice as great.

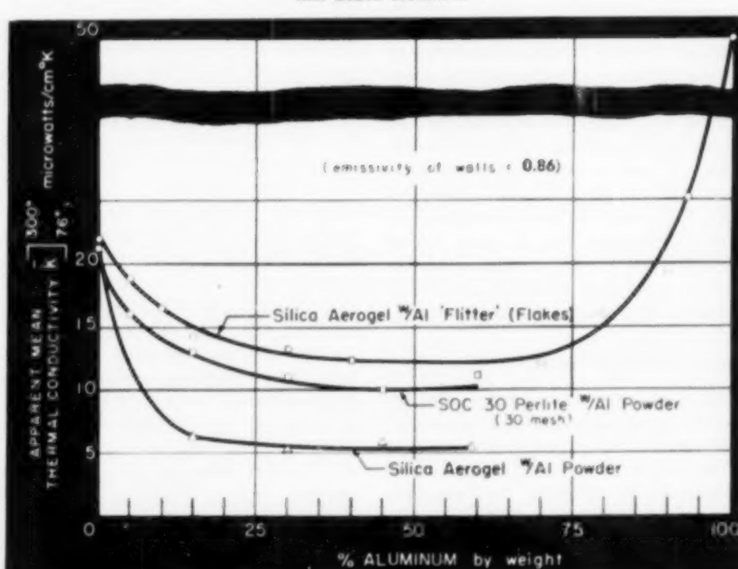
(d) utilizing where available potentially good-reflecting substrate metals, e.g., copper or aluminum sheet or plate. Surface cleaning procedures that avoid work-hardening should be used, e.g., solvent cleaning or electropolishing. The contaminants to be removed will usually be oxides or films of oil or grease.

The residual gas in a Dewar is usually so rarified that the molecules undergo more frequent collision with the walls than with each other, and the heat conduction will be that given by the Knudsen equation for "free-molecule" conduction. This involves not only the properties of the gas but also the extent to which the gas molecules come to equilibrium with each wall during collisions. The latter is described by the accommodation coefficient, a fraction which depends on the properties of both gas and wall and which stands in almost exactly the same relation to gaseous heat conduction at low pressures as the emissivity does to radiation heat transfer. The limited literature on accommodation coefficients is summarized by Partington *(34)*, and the approximate values in Table 5 are derived from low-temperature experiments by Keesom and Schmidt *(35)* using glass and Knudsen *(36)* using platinum. Keesom and Schmidt suggested that the value of the accommodation coefficient is bound up with whether or not a film of the gas is adsorbed on the surface and found that the value tended toward unity as the temperature of the surface was lowered toward the critical temperature of the gas. Like the emissivity, the accommodation coefficient is a surface property and can be greatly modified by variations in the nature and past treatment of the surface.

POROUS INSULATIONS

For small dimensions and where very good vacua and very low emissivities can be achieved, it is hard to surpass the insulating efficiency of the

Fig. 9. Apparent mean thermal conductivity between 300° and 76° K. of Santocel A and perlite with added aluminum.



Dewar. If a lower order of insulation is acceptable or if space is available for large thicknesses of insulation, the use of vacuum can be avoided, and a layer of air or other gas can be used to provide insulation that will be one to two orders of magnitude better than a solid plastic and three or more orders of magnitude better than metals. The thickness of such insulation cannot be increased without limit without suffering the added heat transfer that accompanies convection. Thus in order to minimize convection, it is desirable to subdivide the gas space by means of grains, fibers, or cellular structures (foams) made from poorly conducting solids. Such expanded solids have little effective cross-sectional area for solid conduction and, if granular, may have the conduction paths interrupted by numerous contact resistances. Thus little is added to the already present gas conduction. The porous solid can, in addition, interfere with the exchange of radiation, thus permitting smaller total heat fluxes than in a stagnant gas layer of the same thickness. The conductivity of a gas-filled powder can be strikingly lowered by removing the interstitial gas. The remaining conductivity then is due to radiation and solid conduction, the former usually predominant at room temperature but decreasing the more rapidly with decreasing temperature.

Figures 8 and 10 illustrate these points. Figure 8 shows unpublished National Bureau of Standards, Cryogenic Engineering Lab data on powders. [Diatomaceous earth is a fossil form of silica while perlite is a heat-expanded silicate mineral (*37*)]. At about atmospheric pressure these have nearly constant conductivity since the ordinary gaseous thermal conductivity prevails and is known to be nearly independent of pressure. With decreasing pressure the conductivity begins to fall when the mean free path begins to approach the size of the interstices in the powder. Ultimately free-molecule conduction prevails, and at all lower pressures the gas conduction is proportional to pressure. In the flat low-pressure part of the curve the gas conduction has vanished relative to a constant residual conduction due to radiation and solid conduction. It has been shown that the heat transfer through evacuated silica aerogel varies almost exactly at T_2^4 for values of T_2 near ambient (T_1 held constant).

Consequently, the solid conduction must be negligible compared to radiation in silica aerogel near room temperature, but this situation is undoubtedly reversed at low temperatures. The heat transfer due to radiation can be reduced by addition of an opacifier. Figure 9 shows the effects on silica aerogel and perlite of admixing aluminum powder. Experiments now in progress indicate that mixtures of aluminum powder with $\leq$ 80-mesh* perlite give minimum conductivities as low as those shown for aluminum powder with silica aerogel. (Mixtures of perlite with silica aerogel and diatomaceous earth with silica aerogel were not advantageous.)

Radiation also manifests itself through the apparent conductivity becoming dependent on the thickness and boundary emissivity at small thicknesses of powder. However, these effects are of minor importance for thicknesses greater than 1 in. Table 6 gives a comparison of a number of powders under the test conditions for which the largest amount of data was available.

The variation of conductivity with temperature has not yet been explored in detail. However, one can safely estimate that for $T_2 \approx 300°$ K. and $T_1 \lesssim 100°$ K. the conductivities should not be much different from those given for $T_2 = 300°$ K., $T_1 = 76°$ K. Thus for $T_1 = 90°$ K. (boiling point of O_2) the mean conductivity should be higher by not more than 5%, while for $T_1 = 20°$ K. (boiling point of H_2) or 4° K. (boiling point of He) it should be lower but not by more than 20%.

It has been noted that the conductivities of the upper group of curves in Figure 8 tend to level off at atmospheric pressure at approximately the value of the thermal conductivity of nitrogen for the same temperature (175 microwatt/(cm.)(° K.). Consequently, the apparent powder conductivities in this pressure region for other interstitial gases can be roughly estimated from the conductivities of the gases themselves. Silica aerogel is an exception in that its curve does not level off until pressures well above atmospheric are reached. This is a consequence of its exceptionally small pore size which

* i.e., 80-mesh and finer

Fig. 8. Apparent mean thermal conductivities of some powders. (T_1 and T_2 are the respective boundary temperatures.)

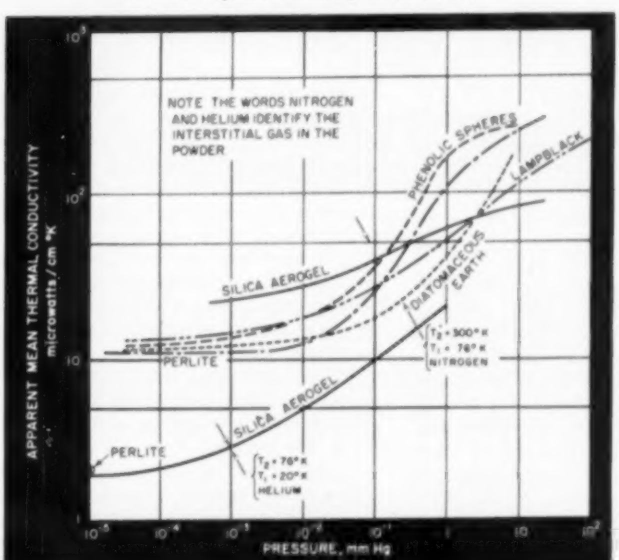


Fig. 10. Apparent mean thermal conductivities of some closed-cell foams.

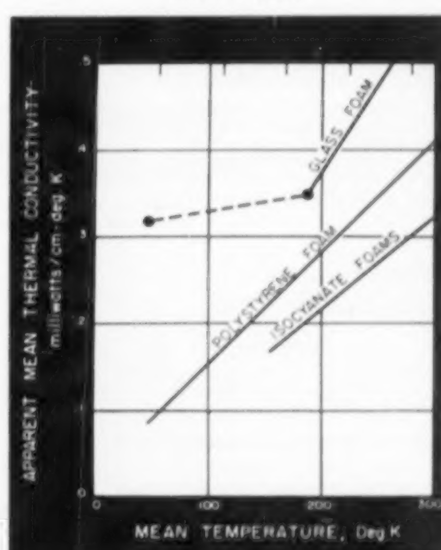


Table 6.—Comparison of Apparent Mean Thermal Conductivities of Evacuated Powders

(NBS-CEL† data for $T_2 = 300°$, $T_1 = 76°$ K. Boundary emissivities were essentially unity. Pressure was below 10^{-4} mm. Hg)

Powder	Sieve mesh, $in.^{-1}$	Density, lb./cu.ft.	Thermal conductivity, microwatts/cm. ° K.
Santocel A		5	22.
Santocel AO*		.....	17.
Perlite	$\leq$80	8.7	10.5
Perlite	30 to 80	8.4	12.6
Perlite SOC	$\leq$30	4.0	21.5
Perlite	$\leq$30	6.6	18.2
Peach pit charcoal	20 to 30	.....	18.
Diatomaceous earth	......	20	11.
Lampblack	......	12	12.6
Phenolic spheres	......	12	12.
Talc	......	75	16.
Fused alumina	50 to 100	125	18.
20% Aluminum powder** 80% Santocel	......	.....	6.
20% Aluminum powder** 80% Perlite ($\leq$80 mesh)	......	.....	6.

* A former Monsanto product using silicon as an opacifier.

** Percentages are by weight.

† Nat. Bur. Standards—Cryogenic Engineering Laboratory, Boulder, Colo.

makes it especially efficient for non-evacuated use.

Figure 10 is synthesized from unpublished NBS-CEL data on foams obtained at mean temperatures of 48° K. ($T_2 = 76°$, $T_1 = 20°$) and about 190° K. ($T_2 = 300°$, $T_1 = 76°$) together with values at higher temperatures published by the manufacturers. The conductivities are for the most part approximately proportional to temperature and this is also the case for the conductivities of most gases. The curve for polystyrene foam is about 50% higher than the similar curve for air. (Although this material is blown with an organic agent, it is permeated by air within a short time.) The isocyanate foams are blown by CO_2 and were measured almost immediately. Their curve is about twice as high as that for CO_2.

Foamglas contains a mixture of CO_2, CO, and H_2. The high value at $T_{avg.} = 48°$ K. is thought to result from the fact that the CO_2 and CO are frozen out at this temperature, so that the high conductivity of undiluted hydrogen gas is realized and, indeed, this point is close to the conductivity of hydrogen at the same temperature. These data, though scanty, serve to illustrate that the conductivities of foams are primarily due to the trapped gas with a substantial added solid conduction, the latter increasing with the foam density. Radiation plays a minor part even at room temperature, especially in the more dense and small-celled foams. It may be expected that measurements at more closely spaced temperatures will disclose a more rapidly changing conductivity in the temperature regions where condensation of the cell gas substantially lowers the conduction.

It is well established that atmospheric gases permeate organic plastics, and this effect can result in substantial changes in the conductivities of foams. It is especially important to prevent permeation by hydrogen since its conductivity is some seven times that of air. NBS-CEL experiments with the isocyanate foams have shown substantial changes in conductivity in a few days time due to CO_2-air or air-H_2 interchange at room temperature. However, permeation rates should decrease rapidly with decreasing temperature.

It is estimated that at room temperature the permeation constant for hydrogen and soft glass (Foamglas) is perhaps 10^5 smaller than for hydrogen and representative plastics and consequently that glass foams will not lose at an appreciable rate hydrogen introduced during manufacture.

Table 7.—Mechanical Properties of Plastics

	T ° K.	Tensile strength lb./sq.in. $\times 10^{-3}$	Compressive yield strength * lb./sq.in. $\times 10^{-3}$	Young's modulus lb./sq.in. $\times 10^{-6}$
Teflon (Polytetrafluoroethylene)	295	2.	....	.06
	195	5.5	....	.26
	153	8.	9.	.54
	77	15.	18.5	.74
	20	....	25.	....
	4	....	27.	1.0*
Kel-F (Polytrifluoromonochloroethylene)	293	6.3	....	.26
	198	14.0	....	.62
	77	16.2	....	.84
	4	....	44.	....
Polyethylene	300	1.3	....	.02
	4	....	25.	....
Polyvinylchloride	293	7.7	....	.52
	198	17.4	....	.55
	77	19.7	....	1.11
Nylon	293	9.5	....	.43
	198	20.1	....	.56
	153	24.3	....	.75
	77	27.9	....	1.10
Mylar (Polyethyleneterephthalate)	300	21.0	....	1.01
	195	27.	....	1.16
	77	31.	....	1.85

* Compression data by Swenson (40). All other values were measured in tension and are from (41) and (42).

Mechanical Properties

METALS AND ALLOYS

It has long been known that steels that are ductile at ordinary ambient temperature may undergo brittle failure at low atmospheric temperatures. Interest in this phenomenon has been stimulated by wartime failures in welded ships and by the need to develop machines that can operate in the Arctic or at high altitude. Fundamental studies have extended our knowledge to other alloy systems and into the range of cryogenic temperatures, and have been augmented by measurements of commercial alloys in support of cryogenic engineering developments. As a consequence there is now an extensive literature (*38*) on metals and alloys including compilations which makes it unnecessary and indeed futile to present a collection of selected data in this review.

Materials that are subject to the ductile-brittle transition can be characterized in terms of the temperature range in which this transition occurs. However, this is sensitive to a variety of

factors. Thus the transition temperature can be considerably depressed by additions of suitable alloying elements, removal of others, or heat treatment. It increases with the complexity of the system of applied stresses and the rate of loading. The last two factors are highly intensified in the conventional notched-bar impact test.

A particular case of brittle behavior is shown in Figure 11(*a*) by tensile data on a low-carbon steel. The features that are to some extent characteristic of this class of materials are (1) the large decrease in elongation and reduction of area occurring in a relatively narrow region of temperature, the brittle transition zone, and (2) the rapid rise in yield strength approaching identity with the tensile strength as the temperature is lowered through the transition zone.

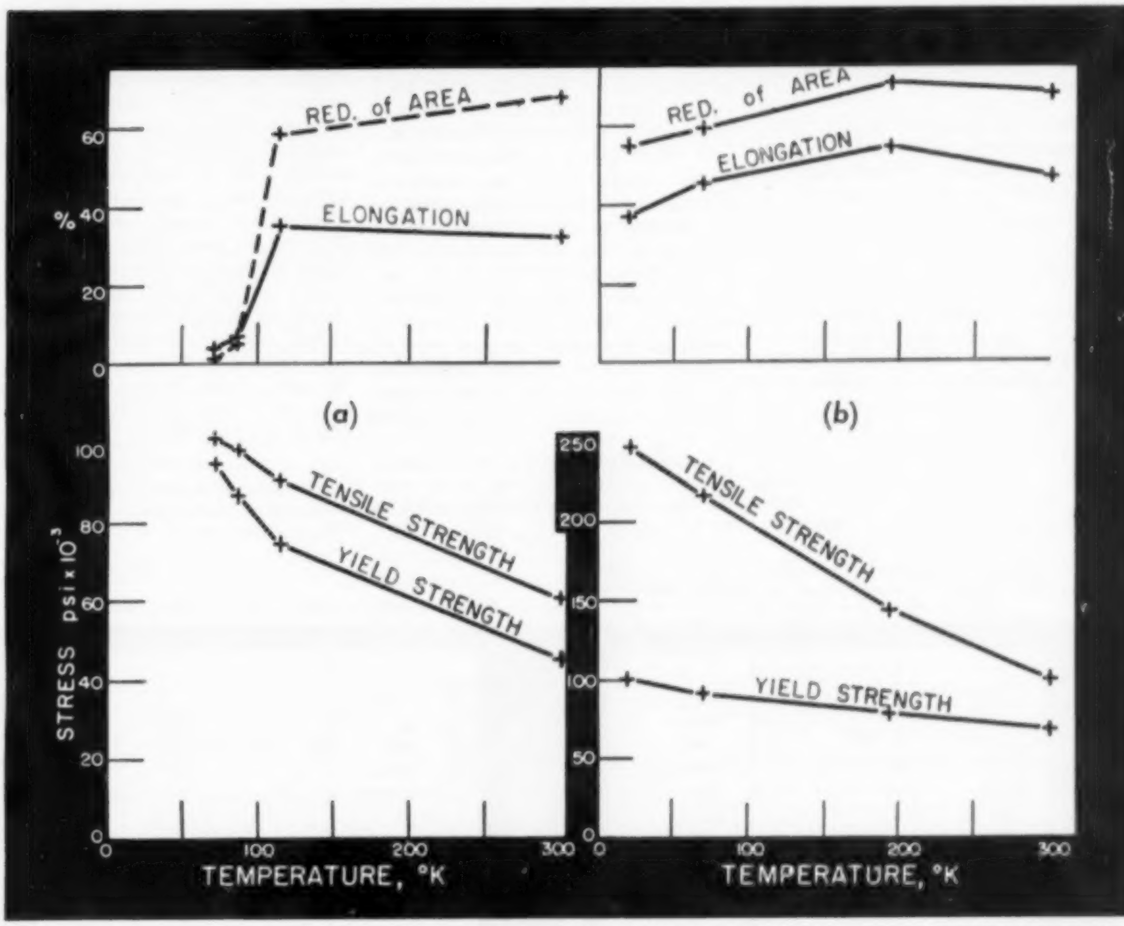


Fig. 11. Tensile properties of two steels: a) low carbon steel, "as received," C—0.15, Mn—0.48, Si—0.25, P—0.010, S—0.029 (38), Teed, p. 50); b) 347 stainless steel, 25% cold drawn (unpublished NBS data).

In contrast, Figure 11(*b*) shows a similar set of properties for type 347 stainless steel, an alloy which apparently is not brittle at any low temperature. Characteristic of the group exemplified by this alloy are (1) the relative constancy of the yield strength, and the increased capacity for work-hardening at lower temperatures as shown by the steep rise of the ultimate strength, and (2) the maintenance of ductility at all temperatures as shown by the high values of the elongation and reduction of area.

The tendency to show a ductile-brittle transition is correlated with the lattice type. Thus the face-centered cubic metals show but few cases of this effect and for structural purposes may be regarded as almost uniformly well behaved. These include copper, nickel, aluminum, the solid solution alloys of each of these, and the austenitic stainless steels. In contrast, body-centered cubic metals for the most part show brittle behavior (though the transition zones of some can be depressed to low temperatures). The ferritic steels are by far the most prominent of these. Prominent among the established structural metals with a different lattice are the hexagonal metals, magnesium and titanium. The impact strength of magnesium is low at all subambient temperatures, the indication being that the brittle transition zone is above room temperature. Limited tests on commercial titaniums indicate that ductility is retained in tension to low temperatures if the amounts of the interstitial solutes, carbon, oxygen, nitrogen, and hydrogen are small. However, notched-bar impact tests show a transition above ambient temperature (*39*).

For temperatures much below 200° K. it is the practice to use the face-centered cubic metals almost exclusively and especially where shock and vibration are encountered. However, less expensive steels can be used in many less critical applications, especially for temperatures above 150-200° K., for example, low-alloy steels, and specially killed carbon steels.

The endurance limit practically without exception increases moderately with decreasing temperature. The same is true of Young's modulus which usually increases by 5 to 30% between ambient and absolute zero. Creep is usually not a problem at low temperatures.

An interesting cryogenic phenomenon which awaits detailed explanation is a form of multiple or repeated discontinuous yielding which sets in at low temperatures. This effect manifests itself through a sawtoothed stress-strain plot and apparently is a general phenomenon that can occur in metals of all lattice types.

PLASTICS

Only a few plastics have been tested at temperatures below 200° K. Of these only Teflon showed ductility down to the lowest test temperature, which was 4° K. (*40*). However, reinforced plastics such as the glass fiber laminates can have good properties, the tensile strength parallel to the laminations increasing at low temperatures and the modulus being approximately constant. While Mylar breaks with fragmentation in a tensile test (*41*) and so is obviously brittle, yet in films of about 0.001 in. or less in thickness it shows remarkable flexibility in bending tests as low as 20° K. Because most data on plastics at low temperatures are not readily available, we reproduce them rather completely in Table 7 and Figures 12 and 13.

Table 8.—Breaking Stress of a Borosilicate Glass
(BSC-2, Corning 8370)

Condition	Rate of stress increase lb./sq.in./sec.	Breaking stress lb./sq.in. 296° K.	194° K.	76° K.	20° K.
Abraded	800	7,500	9,500	10,400	10,400
Abraded	10	5,500	7,500	10,400	10,600
Abraded	1	5,000	6,400	10,400	10,200
Unabraded	800	10,400	.....	18,000	......

GLASS

The strength of glass at room temperature varies inversely with load duration and is sensitive to atmospheric water vapor and to rather minute surface defects (*43, 44*). The dependence on load duration (fatigue) has been found to decrease as the temperature is lowered below ambient but for a soda-lime glass was still appreciable at 83° K. (*43*). Recently Kropschot and Mikesell (*45*) have made measurements on a borosilicate glass down to 20° K. with various constant rates of loading. The results are summarized in Table 8. Apparently the fatigue effect has vanished * and the strength is independent of temperature at and below 76° K. This result is thought to be due to immobilization of the water molecules bound on the surface of the glass and prevention of their usual function of promoting crack propagation. (Others have demonstrated a related effect, the elimination of fatigue at room temperature by removal of the surface water through baking and subsequently testing the glass in vacuum.) Young's modulus was constant within 2% over the temperature range shown. While the mean values of strength are higher for unabraded specimens, the values for these show much more statistical scatter than do those obtained with abraded specimens. Consequently, the mean values for unabraded specimens should not be used for engineering design purposes.

* Additional experiments in which a constant load was maintained for long periods show that there may be a slight fatigue effect at 76° K.

Presented at A.I.Ch.E. meeting, Boston, Massachusetts. Parts 1 and 2 appeared in the June and July issues of CEP.

Fig. 12. Strength of plastics. (+ = Tensile strength; ⊕ = Compressive yield strength). Arrows locate approximate boundaries between brittle and ductile failure.

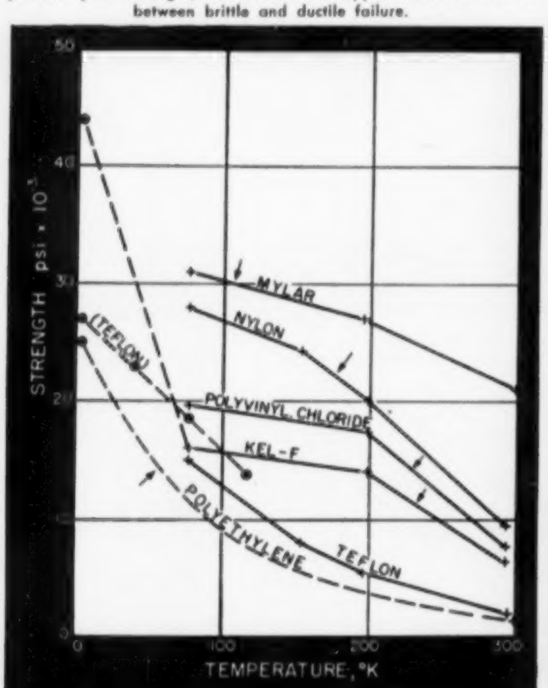
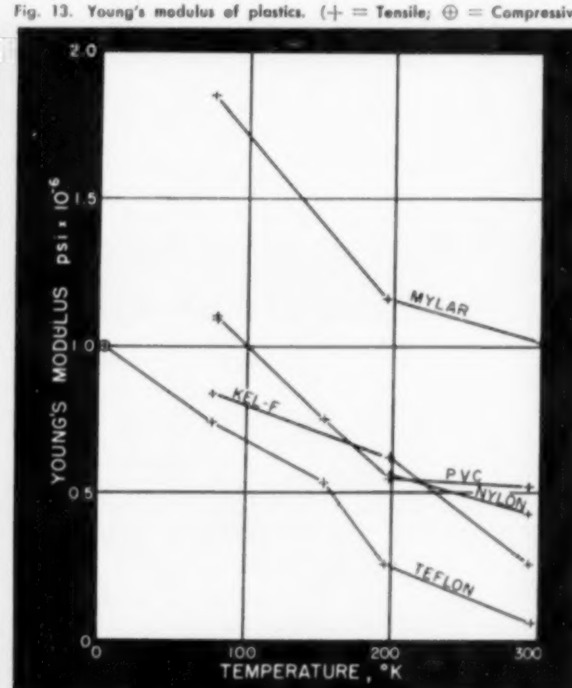


Fig. 13. Young's modulus of plastics. (+ = Tensile; ⊕ = Compressive).



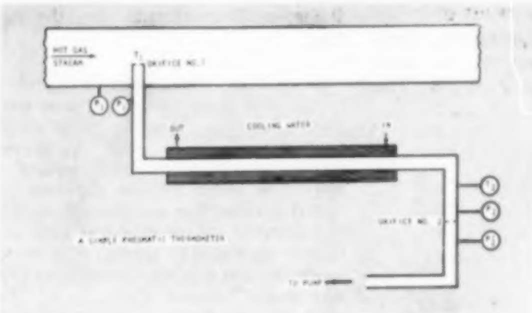


Fig. 1. A simple pneumatic thermometer.

PNEUMATIC THERMOMETER and HYGROMETER

C. L. Coldren and E. W. Comings†* | University of Illinois, Urbana

A simple pneumatic system for measuring temperature is shown schematically in Figure 1 (*2, 3, 4, 6, 7, 9*). This is a thermometer used to measure the temperature of a hot gas, say, at several thousand degrees, where other means are not reliable. A sample of gas is drawn through the first orifice and passed through a cooler in which the temperature is reduced to a range in which thermocouple measurements are accurate. With the exception of T_1 the temperatures and the pressures indicated in that figure are measured. The mass flow rate for incompressible flow through an orifice is given by the equation:

$$w = KA\sqrt{2g_c\rho\Delta P} \qquad (1)$$

For a perfect gas, this equation becomes

$$w = KA\sqrt{\frac{2\ g_cM}{R}\ \frac{P\Delta P}{T}} \qquad (2)$$

The mass flow rate is constant; hence, $w_1 = w_2$ and the following expression for T_1 may be derived:

$$T_1 = \left(\frac{K_1A_1}{K_2A_2}\right)^2 \frac{P_1\Delta P_1}{P_2\Delta P_2}\,T_2$$
$$= K'\frac{P_1\Delta P_1}{P_2\Delta P_2}\,T_2 \qquad (3)$$

One of the chief limitations is evident from Equation (3). The thermometer measures absolute temperature; hence, high precision in the pressure measurements and small deviations from the calibrated values of the orifice coefficients are required to attain a high precision in measuring the temperature. A 1% error in the measured absolute temperature amounts to 10° F. at 500° F., which is rather large compared to the normal errors obtained with thermocouples. Pressure measurements must be precise to better than 1% to achieve normal precision in temperature measurements.

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Table 1.—Orifice and Tube Dimensions

No.	Orifice diameter in.	Tube diameter in.	Ratio β
1	0.062	0.161	0.373
2	0.100	0.500	0.200
3	0.142	0.520	0.269

Measurements in a Spray

The two-orifice system is an attractive method for measuring the air temperature in a spray. A sample of the mixture of spray and air is withdrawn through an orifice, is passed through a heater which evaporates all the water, and finally is passed through a second orifice. Since there is no spray present at the second orifice, the air temperature is measured by a thermocouple. The humidity at the second orifice and the amount of water entering as liquid must be determined. The measurement of humidity at the second orifice is not readily accomplished by wet- and dry-bulb thermometry because the system must be sealed and also because the absolute pressure at the second orifice usually will be greatly different from atmospheric pressure. Psychrometric charts are not available for such pressures. The addition of a third orifice with provision for drying the gas sample between the second and third orifice provides a method for determining the humidity at the second orifice.

Figure 2 is a schematic diagram of the three-orifice meter. The first orifice is operated with the highest reasonable velocity; hence, it is necessary to include corrections for compressible flow in the calibration. For sharp-edged orifices the compressible-flow equation for mass flow rate is:

$$w = KYA\sqrt{\frac{2g_c\rho\Delta P}{1-\beta^4}} \qquad (4)$$

The density of the material flowing through the orifice is given by

$$\rho = \rho_g(1+a) \qquad (5)$$

For the air behaving as a perfect gas the mass flow rate is

$$w = KYA\sqrt{\frac{2g_cMP\Delta P(1+a)}{(1-\beta^4)RT}} \qquad (6)$$

The droplets and the gas in the sample stream enter the probe tube and pass through the first orifice. This orifice has been set back 5 tube diameters from the entrance to the tube just far enough to permit measurement of the pressure P_1, upstream from the orifice. The mixture then is passed through a heater in which all water droplets are evaporated and then through the second orifice. Thus $a_2 = 0$ and $a_1 = H_2 - H_1$. The gas is passed next through a dryer in which all the water is removed and thence through the third orifice. The mass flow rate through the first two orifices is constant, but it is reduced at the third orifice by the amount of water removed in the dryer. Thus

$$w_1 = w_2 = w_3(1+H_2) \qquad (7)$$

The equations for the three-orifice pneumatic thermometer and hygrometer are then:

First, the humidity at the second orifice is given by

$$H_2^2 + \left(1+\frac{M_w}{M_A}\right) + \frac{M_w}{M_A} = \frac{M_w}{M_A}\left(\frac{K_2A_2}{K_3A_3}\right)^2 \frac{P_2\Delta P_2}{P_3\Delta P_3}\ \frac{T_3}{T_2} \qquad (8)$$

The temperature T_1 may be obtained as a function of the humidity at the first orifice H_1 by either of the two following equations:

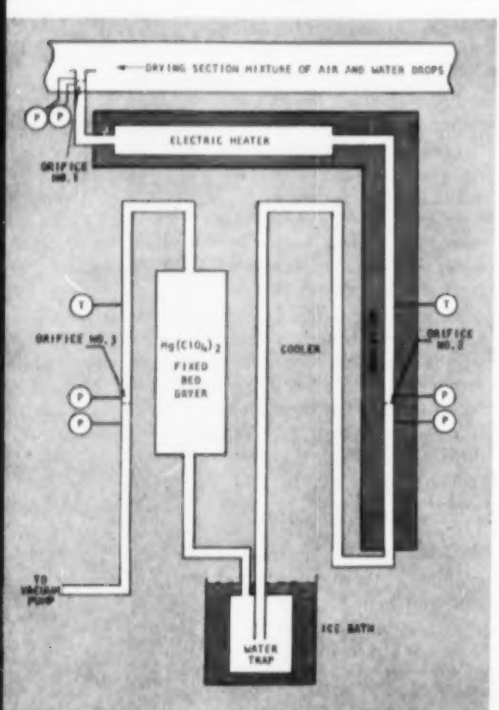
$$T_1 = T_2 \frac{(K_1Y_1)^2P_1\Delta P_1(1+H_2-H_1)(1+H_1)}{(K_2Y_2)^2P_2\Delta P_2(1+H_2)^2\left(1+\frac{M_AH_1}{M_w}\right)} \quad (9)$$

$$T_1 = T_2 \frac{(K_1Y_1)^2P_1\Delta P_1(1+H_2-H_1)(1+H_1)\left(\frac{M_w}{M_A}+H_2\right)}{(K_2Y_2)^2P_2\Delta P_2(1+H_2)\left(\frac{M_w}{M_A}+H_1\right)} \quad (10)$$

If an independent measurement of the wet-bulb temperature at the sampling point is made, say, with a thermocouple, then the gas temperature and humidity may be found by solving either Equation (8) or (9) simultaneously with the psychrometric equation.

If no water droplets enter the orifice, then $a_1 = 0$ and $H_2 = H_1$. In this case, Equation (7) yields humidity directly and Equation (9) yields the gas temperature. The wet-bulb temperature is not required. By the use of proper absorbents, components of the gas other than water vapor can be determined. The use of this type of instrument for gas analysis has not been explored.

Fig. 2. Schematic diagram of pneumatic thermometer.



DESCRIPTION OF THE INSTRUMENT

The design of a pneumatic thermometer and hygrometer has been shown schematically in Figure 2. The three orifices were constructed of stainless steel to the standards specified by the A.S.M.E. (*1*). Table 1 gives the dimensions of the orifices and of the tubes in which they were mounted.

The first orifice was installed in the pneumatic thermometer probe as shown in Figure 3. The probe entered the test stream perpendicular to the direction of the flow. It was expected that a major portion of the droplets would be carried past the probe entrance by the main flow and that a_1 could be kept small. If the fraction of the droplets entering the first orifice is small, then $H_2 - H_1$ will be small and the number of trials required to solve the equations for H_1 by trial-and-error calculation will be held to a minimum.

When making measurements in an air stream with large velocity gradients such that the velocity decreased along the probe tube in the direction of the end of the probe, there developed a flow along the tube. This caused temperatures to be read that corresponded to points displaced along the probe away from its end. To prevent this flow, a thin disk was attached to the end of the probe so that any flow along the tube would be deflected around the probe rather than passing over its end. This arrangement proved successful except for the highest velocity gradients. The gradients that were still troublesome were of the order of 6,000 reciprocal seconds. As long as the velocity increased along the probe away from the end, the flow component was away from the sampling point and produced no undesirable effect. With a probe inserted through the bottom wall of a duct, this meant that readings should be taken only below the centerline of the flow.

The pressure taps used for the orifice in the probe and shown in Figure 3 were vena contracta taps, that is, they were located one tube diameter upstream and approximately 0.75 diameters downstream from the orifice.

Connections were made with rubber tubing, care being taken that these tubes always led away from the probe on the downstream side in order to prevent interference with the main stream of flow. The heater between the first and second orifices was constructed of 2-in. stainless-steel tubing closed at each end. It was packed with copper wool to increase the heat transfer. Nichrome ribbon was wound around the outside. The temperature upstream of the second orifice was controlled manually at or above 250° F. This insured complete evaporation of the droplets in the sample.

The second orifice was preceded by 50 diameters of straight tubing and it was followed by 20 diameters of the same tubing. The air temperature was measured 20 diameters upstream from this orifice by an iron-constantan thermocouple constructed of No. 30 wire. The junction was placed on the center line of the tube.

The heater and the second orifice with its approach and exit sections were heavily insulated by 2 in. of block magnesia. Despite this insulation, there were errors due to cold walls and to a temperature gradient within the airstream. A mercury-in-glass thermometer was embedded in the insulation approximately ½-in. from the surface alongside the thermocouple to help in determining the size of this error.

After leaving the insulated section, the air was cooled by 6 ft. of ½-in. copper tubing. A flask immersed in an ice bath served as a trap for condensed water. The drying bed which followed the water trap, consisted of four parallel passes through 1-ft. deep beds of granular anhydrous magnesium perchlorate in 32 mm. I.D. glass tubes. The beds were repacked with fresh perchlorate after every 4 hr. operating time. Anhydrous magnesium perchlorate is capable of reducing the dew point of air to less than the temperature of liquid air (*8*); therefore, a value of $H_3 = 0$ was taken as valid.

The second and third orifices were identical except for the orifice diameter, and since the gas temperature was now very close to the room temperature, there were no inaccuracies due to variation of the temperature across the tube.

The static pressure upstream from the first orifice was measured with a water manometer and the pressure differential was measured with a mercury manometer. The static pressures at the second and third orifices were measured by mercury manometers and the differential pressures were measured by manometers filled with dibutyl phthalate. The static pressure was less than 10 in. Hg at these orifices.

Table 2.—Special Tests of the Pneumatic Thermometer

Run No.	Temperature: Pneumatic thermometer °R.	Temperature: Thermocouple °R.	Temperature: Difference °R.	Velocity of gas across probe ft./sec.	State of turbulence
806	545	539	6	0	a
807	543	539	4	0	a
808	545	539	6	0	a
809	545	539	6	0	a
810	547	539	8	0	a
811	556	549	7	0	a
812	552	549	3	0	a
813	553	547	6	0	a
814	552	548	4	0	a
815	548	548	0	0	a
816	550	548	2	7.5	b
817	551	549	2	8.6	b
818	550	549	1	9.5	b
819	548	549	−1	10.3	b
820	548	548	0	11.6	b
821	547	548	−1	12.6	b
822	543	546	−3	316	c
823	541	545	−4	267	c
824	541	545	−4	246	c
825	539	544	−5	185	c
826	543	542	1	0	a
827	538	538	0	0	a
828	533	537	−4	0	a
829	539	537	2	0	a
830	538	537	1	0	a
831	537	537	0	0	a
832	539	537	2	0	a
833	535	537	−2	0	a
834	537	537	0	0	a
835	533	538	−5	0	a

a—none
b—low, i.e., normal pipe flow
c—high, i.e., free jet at $x/D = 16$

The iron constantan thermocouples were read on a manually balanced potentiometer to 1° F.

MEASUREMENTS

Tests were conducted to demonstrate the ability of the instrument to measure temperature under the special conditions encountered in a jet spray dryer. Measurements were made in regions of high and low turbulence and in regions of high and low velocity. Results are shown in Table 2. The difference between the temperature measured by the pneumatic thermometer and that measured by a thermocouple was on the average only 0.5%. This is acceptable accuracy for a device which involves six manometer readings and two thermocouple readings. The variation in ambient velocity and temperature was quite extreme. No clear trend with velocity or turbulence was established, and the error was always small. The net average error for all runs was about 0.25% high. When suitably corrected, the pneumatic thermometer and hygrometer gave reasonable results in the jet spray dryer (*5*).

Acknowledgment

C. L. Coldren was a Du Pont Fellow for two years while this work was under way and the assistance of the Du Pont Company is gratefully acknowledged. Partial support was also provided by the U. S. Army Chemical Corps Biological Warfare Laboratories, Fort Detrick, Frederick, Maryland.

Notation

A = area of orifice
g_c = conversion factor, 32.17 (lb. mass)(ft.)/(lb. force)(sec.)(sec.)
H = humidity of air, lb. water vapor/lb. dry air; H_1 upstream from 1st orifice; H_2 upstream from 2nd orifice; etc.
K = orifice coefficient; K_1 for 1st orifice; K_2 for 2nd orifice; etc.
K' = a constant
M = molecular weight; M_w, of water vapor; M_A, avg., molecular weight of air; $M = (1 + H)/(1/M_A + 1/Mw)$, avg. molecular weight of air plus water vapor
P = absolute pressure; P_1, upstream from 1st orifice; P_2, upstream from 2nd orifice; P_3, upstream from 3rd orifice
ΔP = difference in pressure across an orifice; ΔP_1, across 1st orifice, ΔP_2, across 2nd orifice; ΔP_3, across 3rd orifice
R = gas law constant
T = absolute temperature; T_1, upstream from 1st orifice; T_2, upstream from 2nd orifice; T_3, upstream from 3rd orifice
w = mass rate of flow; w_1, through 1st orifice; w_2, through 2nd orifice; w_3, through 3rd orifice
Y = expansion factor for flow through orifices
x = weight ratio of water droplets to air
β = ratio of orifice diameter to tube diameter
ρ = density of fluid; ρ_a, of air

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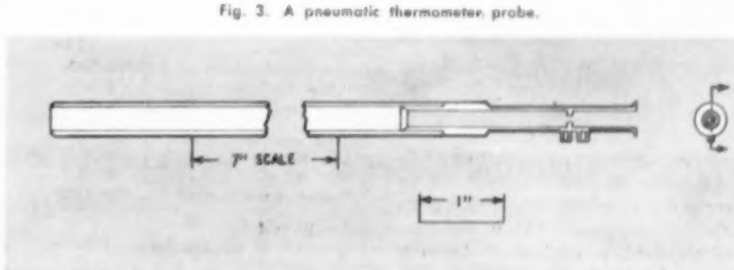
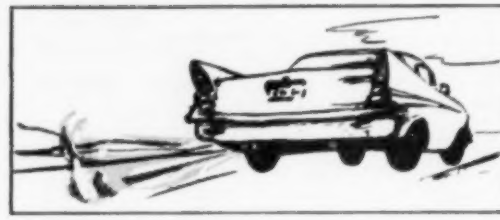
Presented at A.I.Ch.E. meeting, Seattle, Washington.

Fig. 3. A pneumatic thermometer probe.



notes on solving the AUTO EXHAUST PROBLEM in SMOG FORMATION



W. L. Faith | Managing Director, Air Pollution Foundation, San Marino, California

Smog, in the sense it is now commonly used, is not just a mixture of smoke and fog, but any abnormal concentration of matter in the atmosphere which is sufficient to harm or annoy people. No matter how it is defined, or which manifestation of smog bothers people, a relationship can be formed between smog and some constituent of auto exhaust: offensive aldehydes; toxic carbon monoxide, which is a health hazard; unburned gasoline and oxides of nitrogen which can react under favorable conditions to produce eye irritation and to damage vegetation; and smoke from partially burned lube oil that can easily restrict visibility and irritate the lungs in enclosed spaces.

Three Solutions

The solution to the auto exhaust problem depends on how much of which pollutant one must eliminate. In Los Angeles it has been assumed that either unburned gasoline or nitrogen oxides must be drastically reduced in order to solve the problem. Three approaches have been considered seriously: (1) a fuel cutoff device on the carburetor, which would operate during deceleration; (2) a nitric oxide eliminator; and (3) an afterburner in the exhaust system to burn residual organics catalytically or by direct flame. Fuel modification has also been proposed, but would be of doubtful value.

There is some doubt that a carburetor device will remove sufficient organics to be worth while, so emphasis is being placed on the chemical devices.

Currently there are three needs: (1) a catalyst that will speed up nitric oxide decomposition or reduction; (2) an oxidation catalyst that will not be adversely affected by lead compounds in the exhaust gases; (3) in the noncatalytic field, a method of burning the organics in the exhaust in a reaction chamber small enough to fit under a modern car. Each of these three problems is primarily in the field of chemical engineering and chemistry.

Needed: The Market

Of course, research and development cost money and the problem won't be adequately tackled unless there is a reasonable hope of financial gain to the one who solves the problem. Two questions might well be posed: Is there a market for a suitable device? What is the size of the market?

There is definitely a market for nearly 3 million units in the Los Angeles area. The Board of Supervisors of Los Angeles County has said that whenever a practical device is available it will be required by law. The only delay would be the time needed for usual legislative processes and the establishment of an adequate inspection system. Inspection of motor vehicles has never been required in California and probably will not be required until the type of device is known and suitable inspection equipment can be developed.

Although Los Angeles will probably be the first proving ground for such a device, the rest of Southern California, and possibly the San Francisco Bay area, will not be far behind. But potential manufacturers will be even more concerned with the likelihood of broader adoption of an exhaust control device. A restricted market on the West Coast would be of interest to a few manufacturers, but a nationwide market would be preferable.

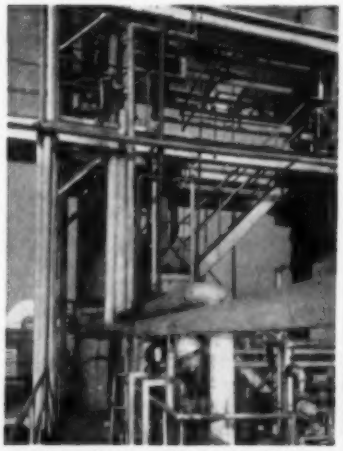
Fortunately, a catalytic or direct-flame afterburner will solve the carbon monoxide problem as well as the hydrocarbon problem, so if an afterburner is adopted on the West Coast, further expansion into Eastern cities might well follow. If a simple nitric oxide eliminator is the answer, wide geographical acceptance may not follow. In those areas where the local problem is aldehyde stench or smoking tailpipes, less expensive solutions will probably suffice.

The most promising areas for research into the motor vehicle exhaust problem are in the development of a lead-insensitive oxidation catalyst, a nitric oxide eliminator, or a small direct-flame afterburner. These are chemical engineering problems, and are strongly recommended to any chemical engineering research organization looking for projects that offer economic rewards and at the same time promote the general welfare.

Condensed from a talk given at fiftieth anniversary meeting, Air Pollution Control Association, St. Louis, Mo.

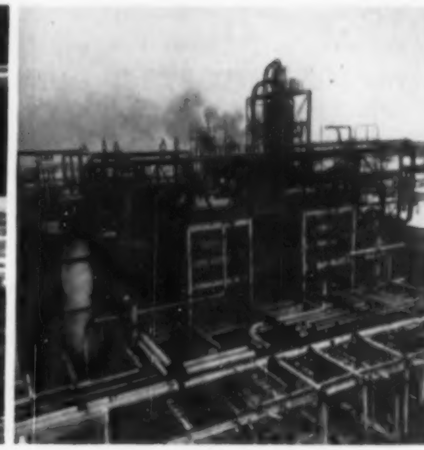
Table 1.—Effect of Engine Operating Conditions on Composition of Auto Exhaust

	Idle	Acceleration	Cruising	Deceleration
Air-fuel ratio	11:1–12.5:1	11:1–13:1	13:1–15:1	11:1–12.5:1
Engine speed (rev./min.)	400–500	400–3,000	1,000–3,000	3,000–400
Air flow (cu.ft./min.)	6–8	30–35	15 35	6–8
Cylinder vacuum (in. Hg)	16–20	0–7	7–19	20–25
Exhaust analysis:				
CO (%)	4–6	0–6	1–4	2–4
NO (p.p.m.)	10–50	1,000–4,000	1,000–3,000	10 50
Hydrocarbons (p.p.m.)	500–1,000	50–500	200–300	4,000–12,000
Unburned fuel (per cent of supplied fuel)	4–6	2–4	2–4	20–60

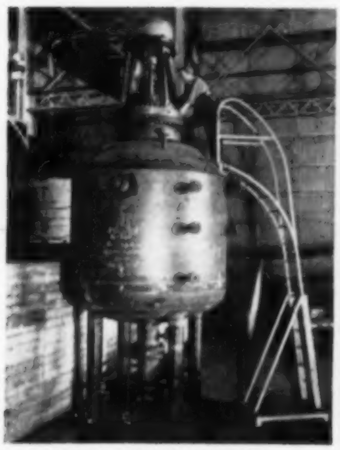


RDC Countercurrent Extraction Column Handling a Total Flow of 2500 GPH

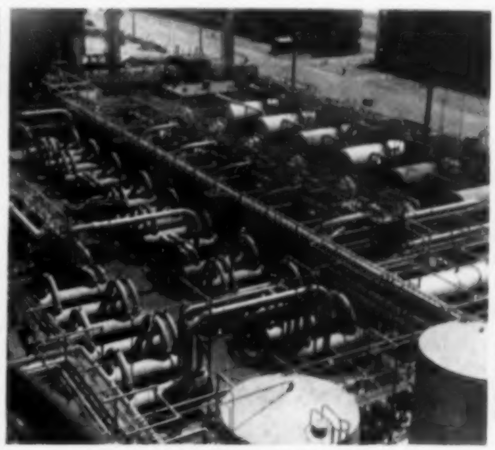
Clay Contactor Treating 135 GPH Stream of Oil



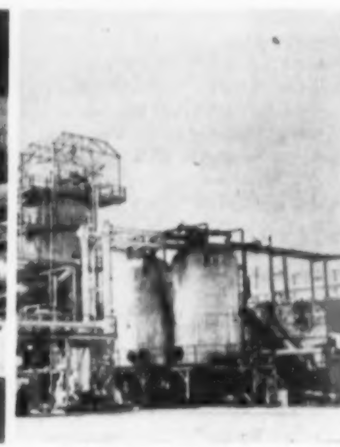
Series of Three Stage Treaters and Settlers in CAA—Butadiene Extraction



Side Entering Propeller Mixer Blending Asphalt Cutback Products



Three Stage Continuous Butane Isomerization Unit



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MAJOR INTEGRATED RUBBER PLANT GOES ON STREAM IN TEXAS

The giant new butadiene plant of Odessa Butadiene Co. is on stream, marks the first integrated operation since World War II in which synthetic rubber is produced from butane at one location.

First major process unit of Odessa Butadiene's new 50,000 ton a year butadiene plant at Odessa, Tex. was completed in June, whole plant went on stream in July. Located on an 80-acre site, the entire $20 million plant was designed, engineered, and constructed by the Fluor Corp. in a fast 12-month construction schedule.

First section to be finished and turned over to Odessa was the butadiene recovery section which will use the CAA (cuprous ammonium acetate) extraction process under license from Esso Research & Engineering Co.

The other major process units of the new plant are a field butane section, a 50,000 ton a year dehydrogenation section, and an absorption and fractionation section.

Butadiene Boom

This is the second major, large-scale butadiene plant to be brought on stream in recent months by Fluor, the other being Texas Butadiene's Channelview plant (*CEP*, May 1957), and the third major expansion in the industry within three months. Notable in these expansions is the bringing up to date of the engineering involved in these plants, with instrumentation assuming a greater and greater importance. Obsolescence is a factor in this new butadiene capacity—the Odessa plant will be only the fourth to use the Houdry dehydrogenation process and one of the previous three is now dismantled.

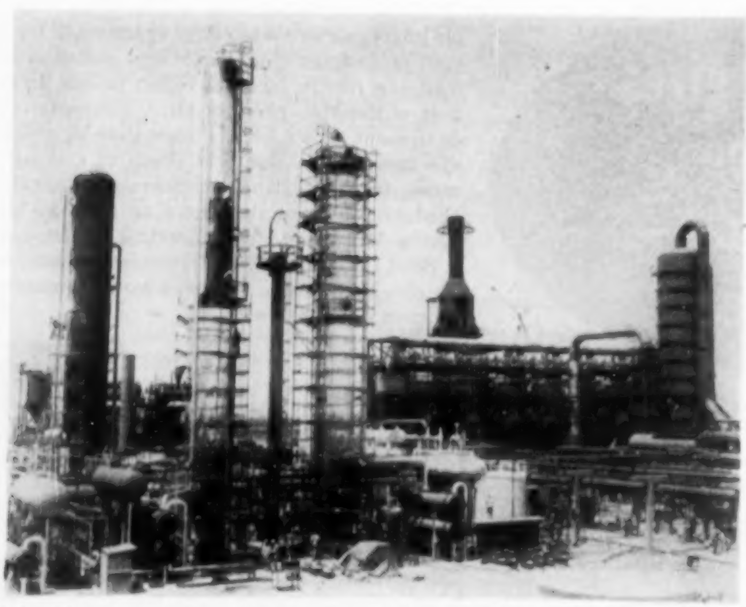
Process Engineering

Although both the Odessa and Texas Butadiene plants were built by Fluor, there are engineering differences of major importance. The Houdry dehydrogenation process is used in both plants, but while the Texas Butadiene plant has two 43,000 ton units, Odessa has one 50,000 ton unit.

Raw material for the Odessa process is field butane produced in the area, which is fractionated into an *n*-butane rich fraction and an isobutane rich fraction. The n-butane is combined with an internal butane-butene recycle stream, preheated, and reacted in the Houdry unit. (Another variant in the Houdry section of the two plants is the use of gas turbine-type regeneration air blowers for the Odessa plant.)

Major difference between the plants is in the recovery of the butadiene from the butane-butylene-butadiene mix. Odessa is using the cuprous ammonium acetate extraction process instead of the furfural process used at Texas Butadiene. In the CAA process a series of mixers and horizontal settling vessels are used to separate the butadiene instead of vertical bubble columns. The butadiene leaves the mixer-settlers dissolved in the cuprous ammonium acetate and a desorber column is used to strip the butadiene from the CAA which is then returned to the mixer-settlers. The process takes place between -10° and 30° F. and refrigeration is required.

A third butadiene job now underway by Fluor is a major expansion at the Lake Charles, La., facilities of Petroleum Chemicals, Inc.



A fast 12-month construction schedule was successfully completed in late July when this Odessa Butadiene plant went on stream at Odessa, Tex.

Expanded engineering and production facilities are in the works for A. A. Straub Co., Inc., of Cleveland, manufacturer of atmosphere generators and allied equipment for the chemical, petroleum, and steel process industries. □

A new operating division to handle products for the chemical, petroleum, gas, and nuclear energy industries is part of a major realignment of the products and plants of ACF Industries, Inc. The new division, to be known as the Advanced Products Division, was established June 1, will manufacture pressure vessels, processing equipment, tanks, etc. □

Purchase of the Aromatic Chemicals Compounding Dept. of Dow Chemical was made on June 1 by S. B. Penick & Co. Under the terms of the agreement, Penick purchased from Dow the entire physical inventory of merchandise and equipment, formulas, trade names, trade marks, and patents. Operations will continue at the present Jersey City, N. J., location for the time being. □

The chemical industry is rapidly becoming the nation's number one user of steel shipping containers. In 1956 the industry used over 30 million units for the shipment of many different products, and currently accounts for 40% of steel drum use, 20% of steel pail consumption. □

A $1.9 million hydrofluoric acid alkylation unit will be built at Enid, Okla., by Badger Manufacturing Co. for the Champlin Oil and Refining Co. of Fort Worth, Tex. The plant will use a process under license from the Phillips Petroleum Co. □

ROTARY PRECOAT FILTRATION

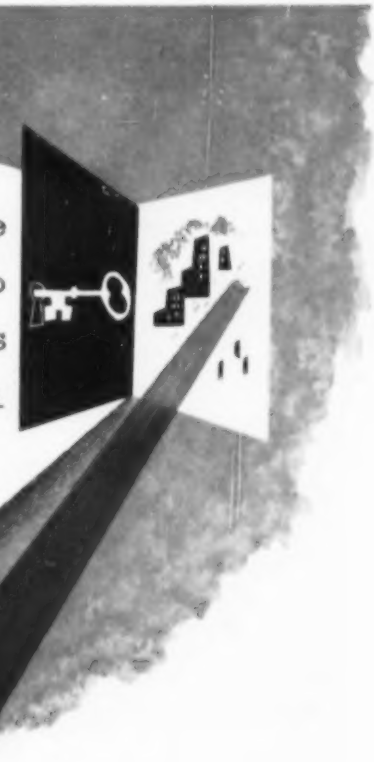
Although rotary precoat vacuum (and pressure) filters have become more and more a factor in filtration, there has been no test device available for the systematic study of filtration rates, filteraid requirements and all the other pertinent operating variables in precoat filtration. Test leaf filters have been used, it is true, but the lack of a precisely controllable shaveoff mechanism, among other things, has limited their usefulness and severely restricted the extension of their results to actual plant scale filtration. Full plant scale tests, though often impractical from the standpoint of time and expense involved, have hitherto been the sole method of working out, accurately, all the variables in establishing optimum performance of precoat filters at the lowest cost. Only those who have struggled with such a test can appreciate the tremendous difficulties in this work. Yet the potential savings in improved operations are so great that a solution of the problem has become imperative.

We believe that the newly-developed, laboratory-scale Dicalite Rotary Precoat Filter Test Leaf, described at the June meeting of the American Institute of Chemical Engineers, in Seattle, goes a long way toward such a solution. This device takes its place as a companion to the well-known Dicalite 'Bomb' Filter, developed earlier for studies in pressure filtration, and widely used for research and control in industrial plants, by filter manufacturers, and in the laboratories of industrial and university research groups.

The new Dicalite filter test leaf is already finding application in the determination of most efficient operating procedures for existing rotary precoat filter installations, and in studies to determine the possible advantages in potential applications. If you have problems involving rotary precoat filters, Dicalite field service engineers will be glad to advise with you, and to discuss the application of this new filter test leaf to the solution of these problems. Filter manufacturers' representatives will soon have this new Dicalite test unit to assist them in their work.

Paul W. Leppla, Technical Director

An avenue opens to new answers in filtration



Filtration studies never possible before except on a pilot plant scale are now made quickly, inexpensively and more accurately through a new development of Dicalite research.

This device, a rotary precoat filter test leaf, is the first precise and practical laboratory-scale device available for study of the process variables in rotary precoat filtration. With it, complete tests of all the major variables can be made in a few hours with a few gallons of process liquor. A long series of these tests has demonstrated that the results obtained with the Dicalite Rotary Precoat Filter Test Leaf show close agreement with those subsequently obtained in full-scale plant operation.

Tremendous possibilities are thus opened up to processing people by this latest Dicalite contribution to the advancement of filtration technology.

For further information please write:

Dependable GLC Great Lakes Dicalite® Diatomaceous Materials

DICALITE DEPARTMENT, Great Lakes Carbon Corporation, 612 South Flower St., Los Angeles 17

INDUSTRIAL NEWS

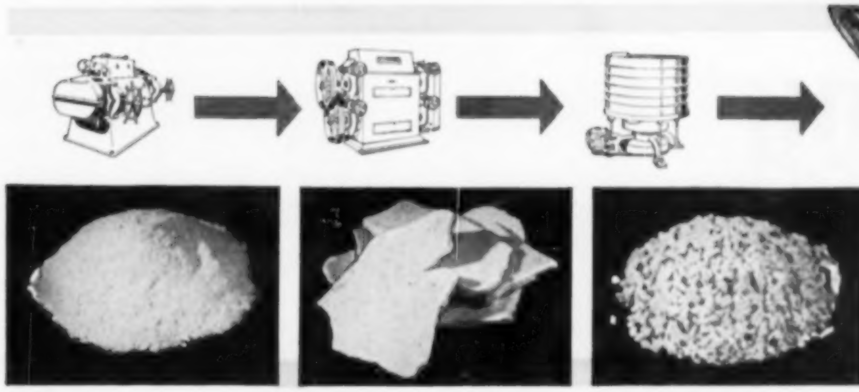
A new $2 million office building and factory addition has been authorized by Superior Tube Co. at its general offices and main plant near Philadelphia. □

The initial multi-million dollar plant of Allied-Kennecott Titanium Corp. will be built at Wilmington, N. C. Production will be titanium forgings and billets, the installation will include a complete laboratory for research and development for the new company whose temporary headquarters will be in Syracuse, N. Y. □

Air Reduction's new $7.5 million-plus liquid oxygen, nitrogen, and argon air-separation plant in Chicago is now on stream. Of completely modern design, with push-button operation from an electronic control panel, this plant will produce 55 tons of high purity liquid oxygen, 15 tons of liquid nitrogen, and 3½ tons of liquid argon a day. The plant has been designed for easy expansion. □

A multi-million dollar expansion of ethylene production facilities has been completed at Monsanto Plastic Division's Texas City, Tex., plant. The new facilities, which will utilize higher feedstocks than propane, will increase Monsanto's ethylene production capacity by 150%. The new ethylene will be used in the manufacture of polyethylene, styrene monomer, and vinyl chloride monomer. □

Furfural, 50,000 to 75,000 tons annually, will soon be produced at this hardwood processing plant by a patented process of the Cumberland Corp., owner and operator of the new plant. While the main product of the plant will be charcoal briquets for the consumer market, furfural production is expected to begin shortly, will be a major product of the new plant.



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it's economical

You start with a pile of practically worthless material and wind up with a profit! Magic? Well, hardly — unless you want to call the mechanical efficiency of the Allis-Chalmers Process System magic.

How It Works

In a recent installation the conversion starts with an unusable, unacceptable minus 30 mesh chemical salt . . . fines created in the original process. An Allis-Chalmers compacting mill densifies these fines into flakes or slabs. Flakes are granulated in an Allis-Chalmers roller mill. Final separation is made in an Allis-Chalmers stainless steel gyratory screen. Result — 70 to 80% recovery of salable product. What's more — the resulting granules equal or surpass the natural product in every respect.

The entire system is mechanical; therefore, it's more economical than controlled crystal growth.

For More Information

Get the complete story from your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. Ask for Bulletin 25C6177J.

ALLIS-CHALMERS

A-5345

The lower half of the fluid coker reactor-fractionator for the $20 million, 11,000 barrel-a-day refinery being engineered and constructed by Fluor Corp. for Pontiac Eastern Corp., is raised into position by giant cranes. Located at Purvis, Miss., the refinery will have in addition to the fluid coker a T.C.C. unit, distillate fractionator, gas plant, H_2SO_4 alkylation unit, unifiner, platformer, treating plant, and sulfur plant.

Two new products for use in high energy fuel applications — lithium perchlorate and lithium nitrate—are now being produced by American Potash & Chemical Corp. The two chemicals are both oxidants to provide oxygen for solid propellants. As oxidants, they can also be used in flares and other pyrotechnics. □

A new multi-million-ton phosphate rock ore body has been indicated by exploration work of San Francisco Chemical Co. on the Hot Springs, Idaho, property of Stauffer Chemical. Extensive underground development work has shown that Stauffer's reserves include at least a million tons of easily minable, high grade phosphate rock which can be used for the economic manufacture of superphosphates. In addition, much more high grade rock is indicated, vast quantities of low grade are proved. □

A 40 million pound increase in the rated capacity of Monsanto's Texas City styrene monomer plant will be completed by June 1958, and a 12 million pound addition to the company's acetylene facilities at the same plant will be completed early in 1958. On schedule are facilities to increase the company's acrylonitrile capacity to more than 100 million pounds, as well as a substantial addition to the polyethylene capacity. □

W. R. GRACE JOINS FRENCH COMPANY TO PRODUCE HIGH-PURITY SILICON

A new company is in the works as a joint venture of W. R. Grace and the giant French chemical company, Pechiney. Plant will be built at an American location as yet unselected, although best bet at the moment seems to be in the U. S. itself near a present Davison Chemical plant.

A sample of high-purity silicon is examined by C. E. Waring, J. Peter Grace, and M. G. Geiger, all of W. R. Grace, which will produce the non-metallic element.

Latest project for an expanding W. R. Grace will be a high-purity elemental silicon plant. To be produced by an as yet un-named joint company of Grace and the French chemical company, Pechiney, the silicon is earmarked for the rapidly growing semiconductor market.

The new company will be operated by Grace's Davison Chemical Division, will probably be in production inside a year (Grace makes no secret of the need for speed in getting to the market since the semi-conductor scene is a rapidly changing one these days, five years could outmode silicon entirely.) Annual capacity of the plant will be in the vicinity of 20,000 pounds.

Where to Build?

Plant location is the major problem at the moment. Favorable atmosphere is important for the ultra-high-purity silicon. Choice of location for the plant will largely determine who will do the actual construction, design, and engineering. Grace tends to look with favor on Puerto Rico as the site, but there are problems, and at the moment a spot in the continental United States is the better bet, with actual site fairly certain to be near a present Davison plant that will not contaminate the silicon.

While this is the initial joint venture in this country between Grace and a foreign company, Grace and Pechiney have worked together in the past. Grace has joint ventures with foreign companies abroad.

During the time needed to construct the new plant, Grace will import the high-purity silicon from Pechiney, will develop its market before the plant goes on-stream. Demand, Grace feels, will depend more on quality than on price. The silicon will probably sell from $320 to $900 a pound for various grades of purity.

PFAUDLER, PERMUTIT TO MERGE

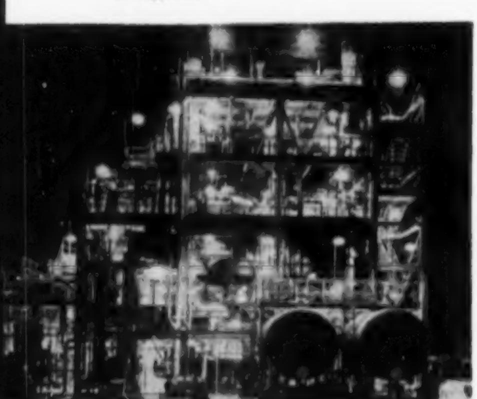
Major process industry merger is in the works as Pfaudler and Permutit boards approve proposal to submit to stockholders.

The proposed merger of Pfaudler and Permutit would bring together the world's largest manufacturer of industrial glassed steel process equipment, and the largest producer of water conditioning equipment and ion exchangers.

Key: Merger could open the way for both companies to assume a major role in the large and growing markets for pollution control and industrial treatment of waste water, could also provide a greater diversification for both companies. Market for pollution control alone is estimated at $120 million.

If the stockholders approve the merger, the basis will be 1.429 shares of Pfaudler-Permutit for each share of Pfaudler, and one share of Pfaudler-Permutit for each share of Permutit. H. W. Foulds, at present Chairman and president of Permutit, would become chairman of the merged company, and R. Miner, at present chairman of Pfaudler, would become vice-chairman of the new company. M. Brugler, president of Pfaudler, would become president and chief-executive officer of the new firm, and D. A. Gaudion, executive vice-president of Pfaudler, would be executive vice-president of Pfaudler-Permutit.

DuPont's new 15 million pound a year Hypalon synthetic rubber plant went into production recently at Beaumont, Texas. Hypalon (chlorosulfonated polyethylene) is a special purpose rubber that resists ozone and oxidation, has many uses including preventive maintenance coatings. When production from this new plant become available, DuPont announced a 15 cents a pound price reduction in Hypalon.



OLIN-MATHIESON DEDICATES NEW HIGH-ENERGY FUEL PLANT

Construction has started at Olin-Mathieson's $36 million high-energy boron fuels plant at Model City, N. Y., which the company will operate for the Air Force.

The laying of the cornerstone at Olin-Mathieson's new plant at Model City has set the Government's high-energy boron fuels program into full swing.

Developments in the new fuels have been swift, include to date:

- Three plants of Olin-Mathieson: a semi-commercial facility at Niagara Falls, owned by the company and making HEF-2, an alkylated pentaborane; an interim plant built for the Navy at Model City; the just-being-built $36 million Air Force plant which will make HEF-3, an alkylated decaborane.
- Callery Chemical's two plants: a $38 million boron fuel plant for the Navy at Muskogee, Okla.; and a smaller "boron chemicals" plant at Lawrence, Kan., for the company itself.
- American Potash & Chemical's pilot plant runs of decaborane.

Process, Production, Cost

Three steps are involved in making boron fuels: making diborane; converting the diborane to penta- or decaborane; alkylating the penta- and decaboranes. To make diborane, the process is reported as a reduction of either boron trifluoride or trichloride

(*Continued on page* 48)

TURN FOR MORE NEWS ON

INDUSTRIAL NEWS

This is the type of electronic computing system (an IBM 705) that will be used by Esso Standard Oil Co. in its new marketing data-processing center to be built in Maryland. The new center will serve all of the company's sales divisions, will receive marketing data by leased telephone wires, will compile or evaluate the data, and will return the necessary reports to the sales divisions by the leased wires.

Union Carbide Corp. and Vanadium Corp. of America have been found not guilty of Dept. of Justice charges of conspiring to monopolize and fix prices in the vanadium industry. Decision was handed down in the U. S. District Court in Denver, Colo. □

A new process for the production of chromyl chloride has been developed by the Mutual Chromium Chemical research specialists of the Solvay Process Division of Allied. Allied has obtained the patent on the new process which features use of the end product as the reaction medium. (Reactor is charged with chromyl chloride from a previous run.)

In the works is a half million dollar expansion of Schutte and Koerting's Cornwall Heights, Pa., manufacturing plant. □

HIGH ENERGY FUELS

(Continued from page 46)

using lithium hydride or sodium borohydride. Diborane is converted to penta- and decaborane by pyrolysis.

Size of the production from the plants involved is secret. From all indications the quantities must still be classified as "small" as far as actual use potential is concerned.

Cost per gallon of the fuels is also a closely kept secret, some estimates range as high as \$11 a pound. Olin-Mathieson itself has mentioned an eventual price of as low as \$1 a gallon, although raw material costs now, and for the near future, make this price seem too low. Defense needs are likely to rule price out as a determining factor anyway. At the moment, chemical engineering seems to be the major factor involved.

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INSTITUTIONAL NEWS

This $1.5 million addition to the Formica resin plant of Formica Corp. (American Cyanamid) at Evendale, Ohio, will be completed by Sept. 1. The new addition will result in a ten-fold increase in space for resin manufacture.

A new million dollar compression fitting plant has been completed by Dresser Mfg. Division at Wellsboro, Pa. The plant is equipped with specially designed, high speed, largely automatic machinery. □

In a recent decision to divest itself of its manufacturing divisions, The Lummus Co. has sold its Heat Exchanger Mfg. Division, Honesdale, Pa. to Yuba Consolidated Gold Fields. At the same time Yuba Consolidated Gold Fields, Yuba Industries, Inc., and the Portuguese-American Tin Co. have joined to form a single company to be called Yuba Consolidated Industries, Inc.

Yuba will assume all contractual commitments and obligations and continue operations of the Lummus Heat Exchanger Division. The purchase (price said to be in excess of $2 million) will give Yuba three divisions in the heat exchanger field: Adsco Division at Buffalo; California Steel Products Division at Richmond, Cal.; and the new Honesdale division. □

A new polyether-based urethane foam has been developed by General Tire & Rubber Co. Called "Polyfoam," the new material is said to have a high tensile strength that enables users to stitch or sew directly through it. The new product is expected by the company to become a major factor in the foam market. □

The new petrochemical plant of Delhi-Taylor Oil Corp., on stream last month, marks the company's entry into the chemical field. Constructed by Treco Co., the new plant will produce 45 million gallons a year of high purity benzene, toluene, and xylene for the plastics, paint, pharmaceutical and other chemical process industries. The plant is a combination of UOP Platformer-Udex unit, equipped with the latest process control systems. □

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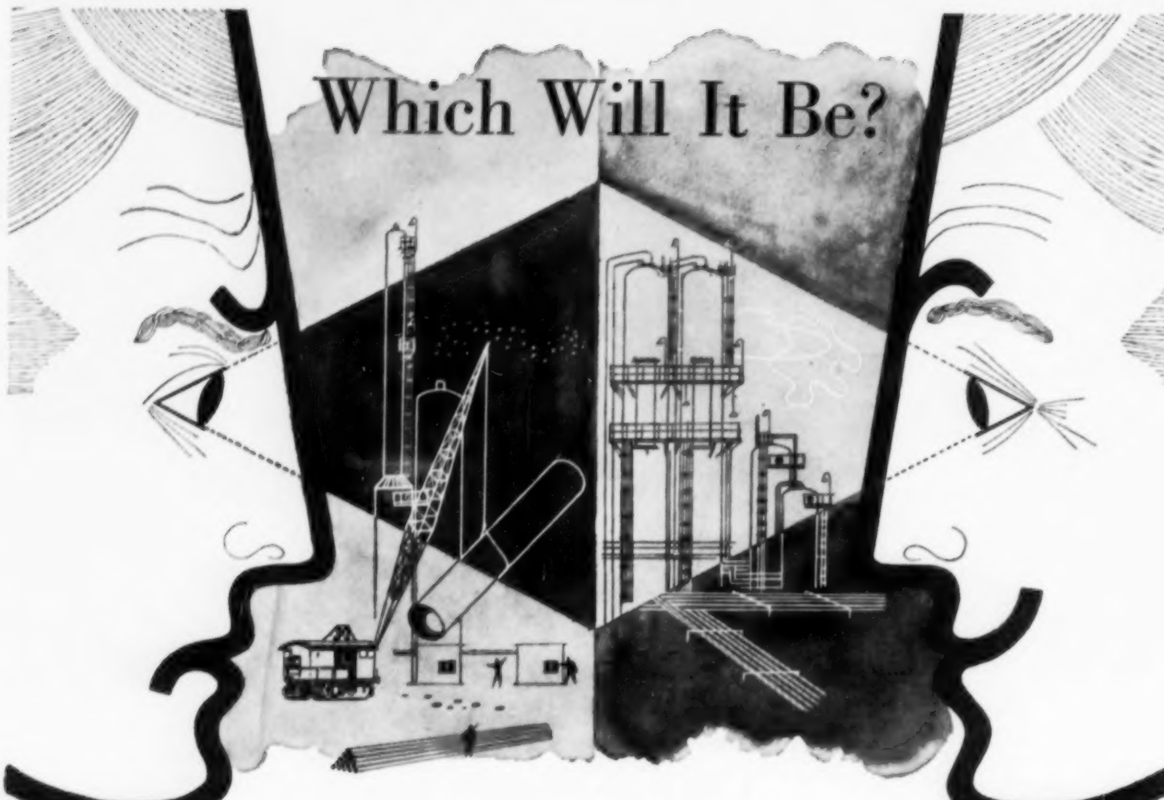

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CEP **Data Service**

DEVELOPMENTS OF THE MONTH

386 New Type Dust Collector. The Mikro-Pulsaire, just introduced by the Pulverizing Machinery Division of Metals Disintegrating Co., features an entirely new design with no internal moving parts. The units consist of varied numbers of cylindrical filter elements, either four or six feet long, enclosed in a dust-tight housing. Dust-laden air is admitted to the housing through a side inlet. Clean air is withdrawn from the inside of the filter elements with an air circulating system. A major portion of the dust material goes directly from the inlet down to bottom discharge of the collector housing, while the balance is retained on the outside surfaces of the filter elements.

Cleaning of the filters is accomplished by momentarily introducing a jet of high pressure air through a specially contoured venturi mounted above each filter cylinder. A single filter element is cleared at a time to maintain a continuous flow of dust through the collector. The jets are controlled by a series of solenoid valves actuated by an electric timer. This timer is adjustable so that the cleaning cycle can be varied to meet different load conditions. Dust recovery efficiencies of 99.9% + are said to have been recorded in tests as well as in field performance. In addition, extremely long filter bag life has been experienced. The range of materials available for the filter bags provides for operation at high temperatures.

Units are constructed with varying numbers and sizes of filter elements. They are available in units with 9, 20, 30, and 48 filter tubes of either 4 or 6 ft. length. Capacities range from 400 and 600 cu.ft./min. of dust-laden air in the smaller of the 9-tube units, to 3,350 and 5,000 cu. ft./min. in the Model 48 unit. Complete technical details are available from the manufacturer. Circle number 386 on Data Post Card.

ENGINEERING DATA—MATERIALS

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(Continued on page 58)

DEVELOPMENTS OF THE MONTH (*Cont.*)

387 Evaporation Inhibitors. Miniature floats, made of foamed polyethylene, are said to reduce evaporation losses from volatile solutions by as much as 75%. The little floats combine the chemical and solvent resistance of polyethylene with a degree of strength which makes them practically immune to breakage or puncturing in use. Four-pointed design facilitates tight clustering and interlocking on the surface of a solution. "Mini-Vaps" are a product of the American Agile Corp. For further information, circle number 387 on Data Post Card.

CEP Data Service

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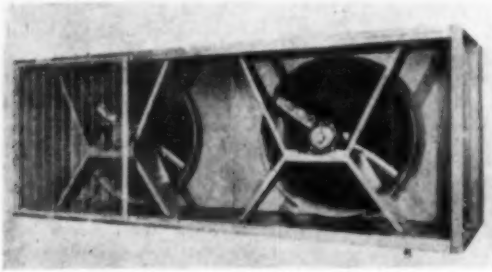
387 Evaporation Inhibitors. Miniature floats, made of foamed polyethylene, are said to reduce evaporation losses from volatile solutions by as much as 75%. The little floats combine the chemical and solvent resistance of polyethylene with a degree of strength which makes them practically immune to breakage or puncturing in use. Four-pointed design facilitates tight clustering and interlocking on the surface of a solution. "Mini-Vaps" are a product of the American Agile Corp. For further information, circle number 387 on Data Post Card.

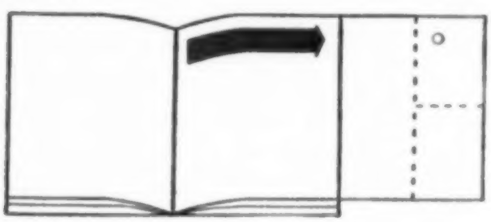
DEVELOPMENTS OF THE MONTH (Cont.)



388 Aero Heat Exchanger. Manufactured by Niagara Blower Co., a new design provides for high heat removal capacity per unit by insuring the movement of air in large volume. Unit consists of an arrangement of heavily-finned tubes in a casing through which air is drawn by two propeller type fans. Heat transfer is from the fluid through the tube walls and extended surfaces to air that is exhausted to atmosphere. The exchangers are built in a range of four standard sizes up to maximum dimensions of 63 in. in height and 126 in. in length. They can be stacked vertically or horizontally in multiple unit installations. Standard construction is hot-galvanized steel surface and casings, but other corrosion materials are also available. Detailed B.t.u./hr. capacity data are available from the manufacturer for fluids having various specific heats. Circle number 388 on Data Post Card. (Continued on page 55)

JUST A MOMENT is needed to learn how to use this insert. When looking through the front part of the magazine, pull the folder portion of the insert out to the right, and the numbers on the post card are convenient for circling.

THEN . . .



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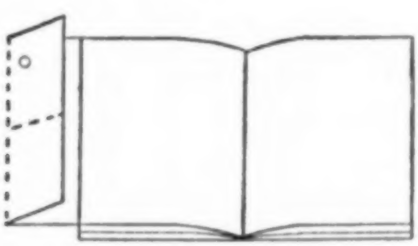

Numbers followed by letters are for checking your interest in the products, equipment, and services advertised in this issue, the number corresponding to the page on which the ad appears. Letters indicate position on the page: L, left; R, right; T, top; B, bottom. A indicates a full page; IFC, IBC, and OBC are cover advertisements. **Numbers in the 300-series** bring you new engineering data in the chemical engineering field.

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30L 31A 32L 33A 34L 35A 36A 38A 364A 39A 41A
42L 43A 45A 47A 48L 49A 50L 51A 52A 57A 59A
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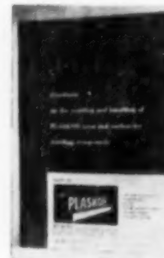
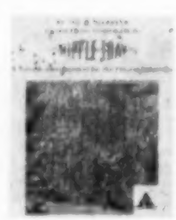
DEVELOPMENTS OF THE MONTH (Cont.)



389 Urea and Melamine Molding Handbook. Barrett Division, Allied Chemical & Dye Corp., offers a 73-page illustrated handbook which details the basic principles of molding and handling Plaskon urea and melamine molding compounds. The manual is a general guide to proper storage, preforming, preheating, molding, finishing, and testing. Illustrations include diagrams and four-color representations of end products. Text is supplemented by charts, graphs, and mathematical and physical conversion tables. Circle number 389 on Data Post Card.

390 Halofluorocarbon Dispersion Coating System. New booklet from Minnesota Mining and Manufacturing Co. describes advantages of the "Kel-F" brand dispersion coating system. Properties offered by this system are said to include chemical resistance, thermal stability, toughness and flexibility, abrasion resistance, dielectric strength, and anti-sticking surfaces. Most metals that can stand temperatures of 475-515° F. can be coated with "Kel-F" dispersions. Exceptions are copper and high copper-bearing alloys. However, it is claimed that application of nickel, silver, cadmium, and lead-tin alloy coatings permit copper to be coated successfully. The dispersions can be applied by spraying, spread-coating, or dip-and-flow coating. Circle number 390 on Data Post Card.



391 "Ripple Tray" Brochure. Recently patented by Stone & Webster Engineering Corp., these trays are designed for use in chemical processing and petroleum refining operations. In a distillation tower, both liquid downflow and vapor upflow occur through the perforations in the trays, so that no downcomers are required. The corrugations or waves in the trays help redistribute liquid as it flows from the bottom of one tray into the froth on the tray below in counter-current contact with rising vapor. High efficiency is claimed over a wide range of loadings. Complete details are available from the manufacturer. Circle number 391 on Data Post Card.

392 Spray Nozzle Catalog. A complete description (48 pages) of spray nozzles with capacities from 1 oz./hr. to 4,000 gal./min. Spray characteristics, construction, materials, and recommended uses are given for many different types of nozzles. The catalog has been planned to facilitate quick and accurate selection for any particular need. All tabulations of capacities and spray angles are based on water at 70° F. temperature. Circle number 392 on Data Post Card.

(Continued on page 58)

PRODUCTS ADVERTISED IN THIS ISSUE

PRODUCTS ADVERTISED IN THIS ISSUE

IFC Urea Synthesis Plants. Vulcan Engineering Division, Vulcan-Cincinnati, Inc. offer 10 ton per day package urea plants, based on the Inventa-Vulcan process.

3R Mechanical Packer Bulletin. Several sizes of "Vibrox" packers available for packing boxes, cans, cartons, kegs, drums, and barrels weighing from 5 to 1,000 pounds. B. F. Gump Co.

4A Mist Eliminators-Entrainment Separators. Yorkmesh Demisters improve performance of vacuum towers, distillation equipment, scrubbers, evaporators. Otto H. York Co.

7A High Octane Gasoline Plant. Eight Blaw-Knox catalytic reforming and hydrogen desulfurization units are now in operation in the petroleum industry for the manufacture of high octane gasoline.

8L Corrosion-Resistant Lining Material. Linings of "Kel-F Laminate" make ordinary equipment resistant to gases and liquids as corrosive as fuming nitric acid. United States Gasket Co.

9A Mixer Catalog. Philadelphia Gear Works offers technical details on horizontal and vertical motor drive mixers.

10A Vinyl Resins. Complete line of vinyls engineered to your specific needs. Technical information and consulting service available from Chemical Sales Division, Firestone Plastics Co.

11A Control Valves. Fisher Governor Co. specializes in the manufacture of valves for the really tough jobs.

13A Steam Jet Ejector Engineering Data. Brochure from Elliot Co. covers single-stage, special corrosion-resisting, and various multi-stage types of steam jet ejectors.

14L Rubber and Plastic Processing Equipment. Piping, pumps, valves, tanks, etc. Bulletins from American Hard Rubber Co.

15A Process Pumps. Full technical details offered by the Aldrich Pump Co. on their complete line of process pumps.

16A Heat Transfer Equipment. In all grades of carbon, alloy, and stainless steels, nickel, aluminum, and special low-temperature materials. General catalog from Efco Heat Transfer Equipment.

17A On-site Oxygen Facilities. Linde Co. will build, operate, and maintain oxygen producing facilities on your own site. No capital investment on user's part and guaranteed price for oxygen.

18A Controlled Volume Chemical Pump. Typical applications, flow charts, descriptions, and specifications in bulletin from Lapp Insulator Co.

21A Leakproof Pumps. Pump and motor combined in single, leakproof unit. No shaft sealing device required. Temperatures to 1,000° F., pressures to 5,000 lb./sq. in. Chempump Corp.

22L pH and Chlorine Control Handbook. W. A. Taylor and Co. offers handbook "Modern pH and Chlorine Control" covering theory and application.

23A-24A Product Bulletins. U. S. Industrial Chemicals Co. offers bulletins on organosodium compounds, titanium tubing, zirconium, and hafnium, many other products and developments.

25A Plant Design and Construction. Cosden's new ultra-fractionating and styrene plant in Texas, designed and built by Badger Manufacturing Co., uses new concept to make styrene directly from gasoline. Brochure available.

27A Process Machinery—High Temperature Equipment. Dryers, roasters, furnaces, reaction vessels, autoclaves. Bethlehem Foundry & Machine Co.

28A Engineering Services. Laboratory and pilot plant testing, flowsheet preparation, economic analysis, plant design and construction. Bulletin from Dorr-Oliver, Inc.

29A Equipment Buyers Guide—1958. Bulletin from Pfaudler Company covers all services, products, and technical aids supplied by them. Other bulletins on individual pieces of equipment.

30L Vacuum Ejectors. Graham Manufacturing Co. specializes in steam or gas operated ejectors, from the smallest to the largest. Consulting services offered.

31A Special Purpose Steels. Booklet "Making the Most of Stainless Steels in the Chemical Process Industries" offered by Crucible Steel Co. of America.

32L Porous Stainless Steel Filters. "Poro-Klean" porous stainless filters are specially adapted to high-temperature, high-pressure applications. Technical data from Cuno Engineering Corp.

33A Mixers. "Readco" mixers are designed for complete dispersion, consistency, uniformity, quality. Read Standard Division of Capitol Products Corp.

34L Swivel Joints. Eight basic styles, over 500 models. From high vacuum to 15,000 lb./sq. in., from sub-zero temperatures to 750° F. Continental-Emsco Co.

35A Sulfur. Sulfur is an important ingredient in the new insecticide Diazinon. Texas Gulf Sulphur Co.

36A Equipment Fabrication. Heat exchangers, pressure vessels, steel and alloy plate fabrication. Bulletin from Downingtown Iron Works, Inc.

38A "Mikro-Pulsaire" Dust Collector. No internal moving parts, radically new method of continuous filter cleaning. Bulletin from Pulverizing Machinery Division, Metals Disintegrating Co.

364A Tower Packing Data. Use of Intalox saddle packing permits lower pot temperatures in vacuum distillation. Bulletin from U.S. Stoneware.

39A Mixing Bulletins. Four bulletins with useful design data offered by Turbo-Mixer Division, General American Transportation Corp.

41A New Type Filter Test Leaf. Rotary precoat filter test leaf makes possible tests of all major variables in a few hours. Technical information from Dicalite Dept., Great Lakes Carbon Corp.

42L Wire Cloth Catalog. 90-page catalog from Cambridge Wire Cloth Co. gives stock list of full range of wire cloth available.

43A Compacting Process. Installation of an Allis-Chalmers compacting process may result in 70 to 80% recovery of salable product. Complete story available from Allis-Chalmers.

45A—New Cellular Plastic Material. "Curon," product of the Plastics Division, Curtiss-Wright Corp., expected to have many important industrial applications.

47A Filters. Available in a complete range of sizes and capacities, custom designed to your application. Eimco Corp. offers expert consulting services.

○ **CHECK** *your Data Service requests on the handy postcard on page 54 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

48L Air Drying Equipment. Niagara Blower Company's controlled humidity method employs "Hygrol" moisture-absorbent liquid. Technical data.

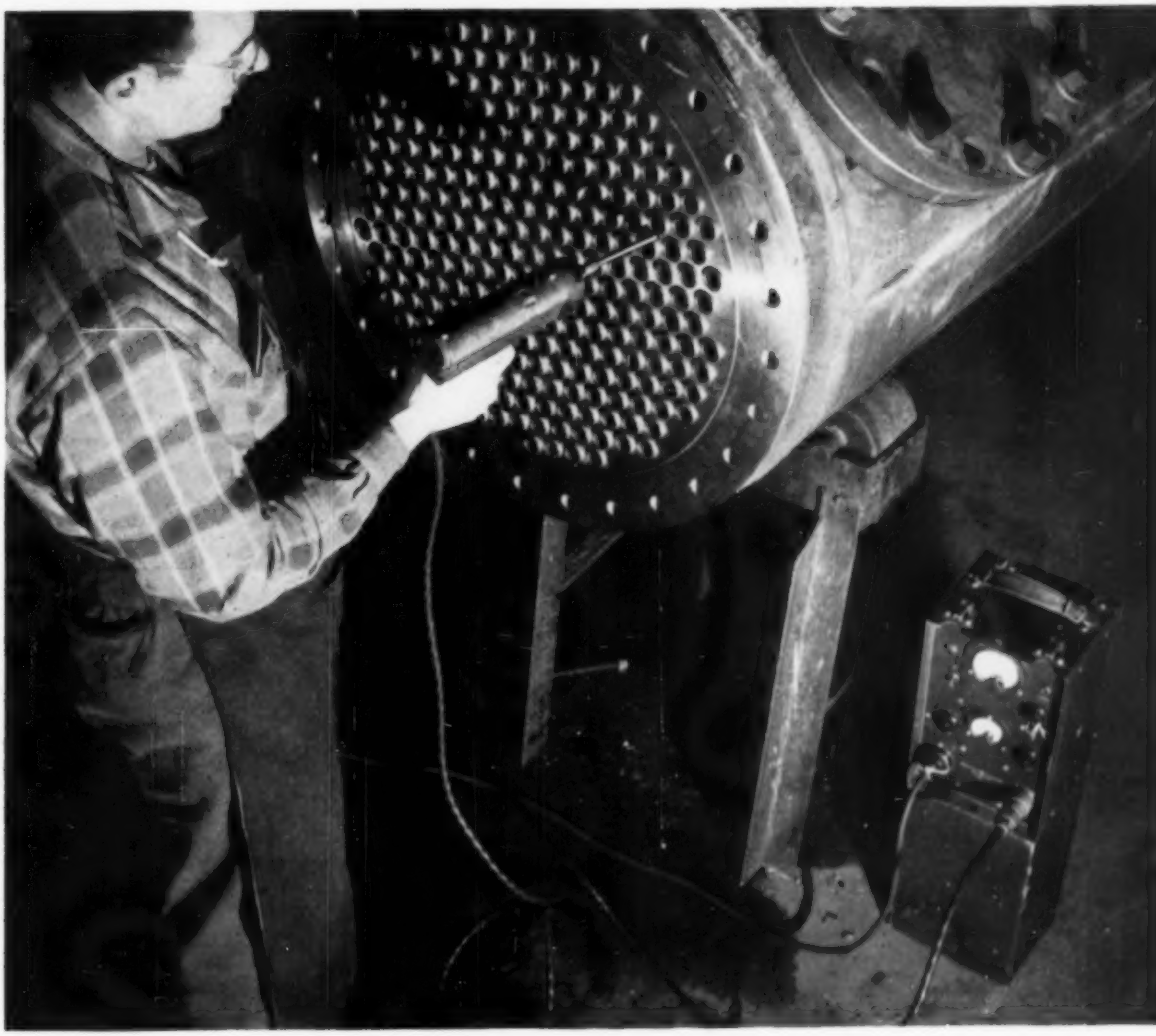
49A "Super" Refractories. Bulletin from Carborundum Co. gives technical data on their line of "super" refractories. Consulting services on high-temperature problems also offered.

50L Tantalum Test Kit. Corrosion test kit, available without charge to research technicians, contains both tantalum sheet and wire. Fansteel Metallurgical Corp., Chemical Equipment Division.

51A Crystallizer Bulletin. Struthers Wells Corp. offers brochure describing their line of "S-W Krystal" crystallizers.

52A Plant Design and Construction. Complete engineering services co-ordinated under a single responsibility. J. F. Pritchard & Co.

57A Heat Exchangers. Modern leak-detection and X-ray tests assure perfect performance of Patterson Kelley heat exchangers.



LEAK DETECTION . . . another reason why you get more for your dollar with p-k heat exchangers

The man above is "snooping" around a P-K heat exchanger to make sure it is leak free. The instrument he's using is an extremely sensitive leak detector which picks up even the slightest trace of a gas or vapor leak. For example, it can detect a leak so small that it would take a year for 1/100 of an ounce of gas or vapor to escape without discovery.

This leak detection test is only one of the many fabricating and testing procedures that make P-K heat transfer equipment the best you can have. For another example, every weld is x-rayed so that any flaw can be eliminated; each tube end is expanded electronically for the most perfect fit. Each unit's thermal rating is scientifically checked to assure that it will perform exactly at its rated capacity.

Precautions like these are the reasons why more and more processors, engineers and contractors are turning to P-K for their exchanger needs. P-K invites your inquiries about the design and fabricating of heat exchangers. Write, phone or visit The Patterson-Kelley Co., Inc., 108 Burson Street, East Stroudsburg, Pa.

Patterson Kelley
Chemical and Process Division

Heat Exchangers • Converters • Storage Water Heaters • Condensers
Storage Chillers • Oil Heaters • and all types of heat transfer equipment

MATERIALS (Cont.)

views use of eight different precipitated calcium carbonates as inert fillers for compounding polyvinyl chloride plastic products.

314 Polyethylene Glycol Bulletin. Use information, physical properties, specifications, and shipping data on three different polyethylene glycols. Olin Mathieson Chemical Corp., Industrial Chemicals Division.

315 Polyvinyl Chloride Products. Engineering bulletins from Kaykor Industries gives corrosion and other technical data on "Vyflex F-92" unplasticized polyvinyl chloride and "Vyflex L-10" flexible lining material.

316 Essential Oils, Aromatic Chemicals. 11-page catalog and price list from Fritzsche Brothers, Inc. covers wide selection of essential oils, aromatic chemicals, concentrates, oleoresins, etc.

322 Technical Bulletin on Caustic Soda. 36 pages of information on physical and chemical properties and handling of caustic soda. Hooker Electrochemical Co.

323 Information on Zirconium. Prices, availability, properties, fabrication, and application of zirconium sponge and ingot. Carborundum Metals Co., Division of Carborundum Co.

324 Butanol Data Folder. Physical and physiological properties, specifications, shipping information, solubilities, constant-boiling mixtures, applications of butanol. Many charts. Union Carbide Chemicals Co.

325 Indicating Silica Gels. Davison Chemical Division of W. R. Grace & Co. offers comparative data on indicating silica gel products, used to show changes in relative humidity by changes in color.

326 High-Temperature Insulation Brochure. Properties, technical data, insulating efficiency, resistance to vibration of "Micro-Quartz" and "Glass Micro-Fibers" high-temperature insulation. L.O.F. Glass Fibers Co.

317 Antioxidant for Polyethylene Plastic. "Santonox" said to protect high and low-pressure polyethylene against degrading effects of heat processing. Bulletin from Monsanto Chemical Co.

318 Hydrazine Derivative Data Bulletin. Properties, specifications, applications of three new hydrazine derivatives: hydrazine dihydrochloride, hydrazodicarbonamide, and monohydrazinium phosphate. Olin Mathieson Chemical Corp.

319 High-Strength Aluminum Alloy. New alloy X5454 displays maximum strength and corrosion resistance at temperatures from 150 to 300° F. Technical data from Aluminum Co. of America.

320 Lithium Compound Data Sheets. Properties, analysis, and handling precautions for anhydrous lithium perchlorate and lithium nitrate. American Potash & Chemical Corp.

321 "Chromallized" Steel Data. 4-page bulletin from Chromalloy Corp. gives case histories, performance test results, heat treatment information on iron and steel treated by high-temperature diffusion of chromium into the surface.

DEVELOPMENTS OF THE MONTH (Cont.)

393 All-Nylon Molded Filters. New, all-Nylon filters designed to withstand rust and corrosion in a wide range of applications are announced by Danielson Manufacturing Co. They consist of one-piece Nylon moldings with Nylon mesh and supporting structural frame injection-welded together in a permanent bond. These "Danco" filters are custom molded in types, sizes, and shapes to meet any specific filtering requirement. Complete design and engineering information is available from the manufacturer. Circle number 393 on Data Post Card.

(Continued on page 60)

SERVICES

327 Chlorine Handling Information. Technical bulletin from Fischer & Porter Co. on handling of chlorine liquid and gas from container to dispenser. Also data on design and construction of chlorine supply systems.

328 Radiation Rental Facility. Bulletin from High Voltage Engineering Corp. describes control system, radiation-dose monitoring, performance capabilities of facility available on time rental terms.

329 Oil Burning Manual. Data, formulas, general information leading to improved performance and efficiency of combustion systems. Cleveland Fuel Equipment Co.

330 Polymer Pilot Plant Engineering Data. 19-page brochure from Crawford & Russell, Inc. describes all phases of design, construction, and operation of polymer pilot plants.

331 Percolation Adsorptive Process Brochure. Discusses static and moving bed processes, thermal regeneration. Many design equations, including maximum permissible flow rate. Minerals & Chemicals Corp. of America.

332 Anti-Corrosive Tank Lining. Old tanks can be converted into usable systems by new lining techniques developed by Haveg Industries. Technical details on request.

EQUIPMENT

333 Centrifugal Process Pump Bulletin. Dimensions, standard materials, pressure and temperature limitations of pumps for corrosive and non-corrosive service. Worthington Corp.

334 Precision Electronic Instruments. For the detection, analysis, control of interfaces in oil-water mixtures or other aqueous solutions in hydrocarbons. Bulletin from Oil Well Water Locating Co.

335 Rotameter Guide. Disc type selection device serves as guide to full line of instruments made by Brooks Rotameter Co.

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336 Telemetering Systems. Bulletin from Techniflex Manufacturing Co. describes theory and operation of telemetering and supervisory control systems.

337 Portable Pumping Unit. Mounts corrosion-resistant centrifugal or positive displacement pumps. Wide selection of pumps and impellers available. Eco Engineering Co.

338 Circulating and Coolant Pumps. For sidewall or immersion mounting. No stuffing boxes, no pump bearings, no couplings. Bulletin from Ingersoll-Rand.

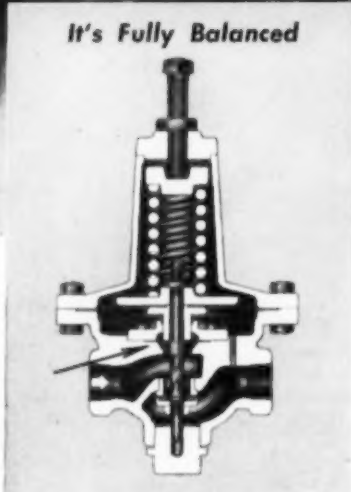
339 Leakproof Pump. Basic design of the "Chempump" eliminates all packing or mechanical seals. Bulletins from Chempump Corp. describe application to many chemical processing problems.

340 Industrial Thermowells. More than 5,700 different combinations to meet all conditions of temperature, environment, and installation. Specification charts and ordering instructions in bulletin from Thermo Electric Co.

341 Air Valve Catalog. Complete specifications, useful charts, and operating data for Crispin air and vacuum, pressure air, and

(Continued on page 60)

Here is the new LESLIE "HI-FLO" Water Reducing Valve with 50% more capacity



Unique construction of "Hi-Flo" Reducing Valve. Note the small lower diaphragm that provides fully balanced, floating action.

HERE IS THE ALL NEW Leslie Reducing Valve with *capacity-regulation* features that have never been offered before. Here is a regulator with 50 - 100% greater capacity by actual test.*

Here's the unbeatable combination of design features:

"HI-FLO" — Large bowl construction; long stroke diaphragm gives full flow of water and other non-corrosive liquids.

FULLY BALANCED — The main valve, fully balanced by lower diaphragm, virtually floats to provide smooth, friction-free, throttling action.

DROP-TIGHT SHUTOFF — Resilient seating disc provides tight closure under all conditions.

TROUBLE-FREE DESIGN — Chatter and hammer eliminated; no piston cups or seals to clog or change. Corrosion resistant trim with renewable interchangeable fit.

Ask your Leslie Engineer to show you how the exclusive Leslie "Hi-Flo" valve can be used to your advantage in water reducing stations, fuel oil pressure control, process lines, etc. He's in your classified directory under "Valves" or "Regulators".

Write today for Bulletin 553 for graphic performance comparison and complete capacity data.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 241 GRANT AVENUE, LYNDHURST, NEW JERSEY

CONTROLLED QUALITY MEANS QUALITY CONTROLS

EQUIPMENT (Cont.)

universal air valves. Multiplex Manufacturing Co.

342 Stainless Steel Liquid Meters. Bulletin from Neptune Meter Co. gives detailed illustrations, meter and register specifications, and list of corrosive liquids which can be handled with new line of meters.

343 Short-Coupled Vertical Pumps. Recommended for cooling towers, circulating or process pumping, etc. Bulletin from Layne & Bowler, Inc.

344 Dynamic Process Control Systems. 23-page bulletin from CDC Control Services, Inc., describes employment of computer techniques and circuitry to program and regulate one or a number of transient process variables.

345 Low Temperature Valves. Operation at minus 300° F. at pressures of 150 to 600 lb./sq.in. In gate and globe designs from ½ in. to 12 in. Valve and Fitting Division, Cooper Alloy Corp.

346 Ion-Exchange Water Demineralizers. Produce high-purity demineralized water at low initial and operating cost. Bulletin from Enley Products, Inc.

347 Oil Cooler Bulletin. Design and operating features, material specifications, sizes and dimensions, and handy sizing system. Schutte and Koerting Co.

348 Controlled Volume Pumps. Recommended as final control elements in proportioning and control systems for blending, formulating, and chemical feeding. 32-page bulletin from Milton Roy Co.

349 Shell and Tube Heat Exchangers. Bulletin from Condenser Service & Engineering Co. gives engineering and reference data on complete line of exchangers.

350 Mechanical Seals. Specially designed for boiler feed pump and other hot water services. Bulletin gives technical and installation data. Crane Packing Co.

351 Dredge Pumps. Available in sizes from 6 in. through 16 in. Prices and detailed information from Thomas Foundries, Inc.

352 Bulk Handling and Storage Equipment. Vertical and horizontal tanks, pneumatic conveying equipment and systems. Bulletin from The Day Co.

353 Metallic Gaskets. Catalog from Metallo Gasket Co. gives cross sections, standard dimensions, applications, and recommendations.

354 Wet Mixing and Homogenizing Equipment. 24-page catalog gives technical details of colloid mills, "Homo-Mixers," and "Agi-Mixers." Gifford-Wood Co.

355 Stainless Steel Reactor Bulletin. Complete specifications of vessels with capacities from 5 to 2,000 gallons. The Pfaudler Co.

356 Corrosion-Resistant Fittings. 21-page catalog from Horace T. Potts Co. gives dimensions, specifications of "Speedline" corrosion-resistant fittings.

357 Turbine Flow Meters. Capacity from less than 1 to more than 2,500 gal./min. Accuracy is plus or minus ½ of one per cent of instantaneous rate. Catalog from Fischer & Porter Co.

358 Guide to Valve Seat Materials. Brochure from Keystone Valve Corp. contains comparative guide of chemical resistant characteristics of various metals and resilient seat materials.

359 Centrifugal Dust Separator Bulletin. Air flow resistance and dust recovery curves, temperature and pressure correction formulas, selection chart, dimensions, supports, and accessories. Day Co.

360 Cord Impregnation Pilot Unit. Versatile, pilot-scale treater accommodating whole range of process variables in cord and strand impregnation. Bulletin from C. A. Litzler Co.

361 Improved Mass Spectrometer. Applications, principles of operation, accessories, specifications, described in brochure from Consolidated Electrodynamics Corp.

362 High Pressure & Temperature Pipe & Tubing. Condensed data on mechanical properties, creep strength, hot and cold bending, welding, heat treatment, working pressure. Bulletin from Babcock & Wilcox Co., Tubular Products Division.

363 Demineralization by Ion Exchange. 19-page brochure from Permutit Co. discusses principles of ion exchange demineralization including silica removal. Many flow diagrams.

364 Process Equipment Fabrication. Puget Sound Fabricators offers a complete custom fabricating service for the process industries. Bulletin.

365 Refinery Process Pumps. Component interchangeability is major advantage of Types PR and PRS refinery process pumps described in new bulletin from Peerless Pump Division, Food Machinery and Chemical Corp.

366 Wire Cloth Products Manual. 94-page book from Cambridge Wire Cloth Co. describes company's complete line of industrial wire cloth, screens, and wire cloth products.

367 Totally-enclosed & Explosion-proof Motors. Approved for highly dangerous locations in proximity to explosive gases, combustible dusts, and hazardous liquids. Brochure from U. S. Electrical Motors, Inc.

368 Mixer Bulletin. Describes complete lines of double-arm, spiral-ribbon, and vertical mixers for pilot plants or commercial production. Read Standard Division of Capitol Products Corp.

369 High Pressure Reactor Brochure. Autoclave Engineers offer bulletin on high pressure reactors for service up to 100,000 lb./sq.in.

370 Ball Joint Bulletin. 6-page brochure from Barco Manufacturing Co. gives details of flexible ball swing, swivel, revolving, and other types of movable joints.

(Continued on page 62)

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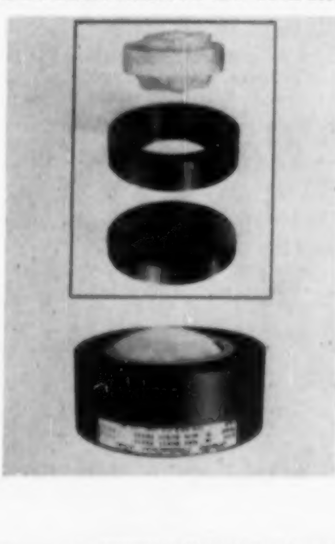
DEVELOPMENTS OF THE MONTH (Cont.)



394 Impervious Graphite Rupture Disks. "Impervite" high temperature disks are now available from Falls Industries, Inc., for operating temperatures up to 650° F. The disks are stated to be accurate to plus or minus 5 per cent of rated burst, and to be suitable for use at 75% of rated burst. They are unaffected by practically all corrosives and their burst characteristics are not affected by varying temperature.

Standard diameters are available from 2 to 12 in. for pressures from full vacuum to 100 lb./sq. in. On order, disks can be furnished up to 24 in. diameter at burst ratings to 250 lb./sq. in. They are suitable for use with either gas or liquid and are designed for mounting in standard A.S.A. flanges.

Additional technical information will be furnished by the manufacturer. Circle number 394 on Data Post Card.

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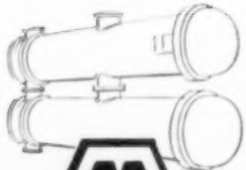


371 Filters for Corrosive Liquids. Bulletin from R. P. Adams Co. gives dimension drawings, specifications, typical systems, and cross section drawings.

372 Vaporizing Unit and Storage Vessel. Produces low-cost gas from liquid oxygen or nitrogen using ambient air as heating source. Details, specifications, and prices available from Hofman Laboratories.

373 Rotary Batch Blender Brochure. Sturtevant Mill Co. offers bulletin with technical information on nine models of blenders.

374 Spray Dryer Bulletin. Bulletin from Proctor & Schwartz gives dimensions and specifications of line of pilot plant and semi-works spray dryers.

375 Furnace Manual. Petro-Chem Development Co. offers 1957 edition of "Petrochem Isoflow Furnace Manual." 116 pages with data from 1,650 additional installations.

376 Corrosion Resistant Equipment. General catalog from Duriron Co. describes special alloys, pumps, valves, heat exchangers, other corrosion-resistant process equipment.

377 Teflon Back-up Rings. For use in conjunction with O-ring seals in hydraulic and similar pressure systems. Technical data and samples available from Sparta Manufacturing Co.

378 Centrifugal Compressor Bulletin. 24-page booklet gives construction details, application data, and dimensions on Series RS centrifugal compressors, made by Cooper-Bessemer Corp. in capacities from 1,000 to 100,000 cu.ft./min.

379 Air-Swept Pulverizers. Bulletin from Schutz-O'Neill Co. gives construction and operation features for controlled ultra-fine pulverizing, classifying, and conveying in one continuous cycle. Cutaway views and circuit diagrams.

380 Chemical Proportioning Pumps. Complete selection charts for pressures to 60,000 lb./sq.in. and capacities to 31.21 gal./hr. American Instrument Co.

381 Vapor Phase Chromatographic Unit. The "Chromagraphette Series 9490," product of Podbielniak, Inc., is a desk model designed for simple and rapid analysis of large group of gases and vaporizable mixtures. Technical data.

382 Dust and Fume Eliminator Bulletin. Brochure from Schmieg Industries describes new wet method vertical rotor type dust and fume eliminator.

DEVELOPMENTS OF THE MONTH (*Cont.*)

395 Large Capacity Spray Nozzles. Wide angle, full cone center jet spray nozzles for chemical processing, quenching, and other industrial applications are now available from the Spray Engineering Co. in the large capacity range, with a spray angle of from 120 to 140°.

The nozzles feature easily removable, streamlined multivaned centers to insure uniform distribution and maximum atomization. Standard nozzles are made of brass, cast iron, steel, and stainless steel, but special nozzles can be made to order from any machinable material.

A complete catalog covering the new line of nozzles is available from Spray Engineering Co. Circle number 395 on Data Post Card.

(Continued on page 64)

383 Graphite Burst Disc. Easily replaceable, accurate to plus or minus five per cent of rated burst pressure. Details from Delanium Graphite Co.

384 Linear Integrator. Provides continuous integration in any instrument or system where integration, area or average computations, and a direct or remote reading is required. Details from Librascope, Inc.

385 Teflon Gaskets and O-Rings. Brochure from Crane Packing Co. describes complete line of gaskets, back-up rings, and O-rings in full range of standard sizes.

○ **CIRCLE** *your Data Service requests on the handy postcard on page 54 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

59A Reducing Valves. Bulletin from Leslie Co. gives graphic performance comparison and complete capacity data.

61A Heat Exchanger Fabrication. M. W. Kellogg Co. will assume design, engineering, and fabrication, or will build to customer's design.

65A "Turba-Film" Processor. Many applications to heat and mass transfer operations involving vapor-liquid equilibria. Details from Rodney Hunt Machine Co.

66L Venting Manual. Operating features and special applications of line of vapor conservation vents. Protectoseal Co.

67A Process Drying Services. Proctor & Schwartz, Inc., offers guaranteed dryer performance based on carefully-planned test programs.

69A Design and Engineering Services. More than twenty Foster Wheeler process installations totalling more than a million tons capacity per year are now in operation or under construction.

70L Corrosion-Resistant Equipment. Heat exchangers, process tanks, fume ducts, piping, pumps, valves. Haveg Corp.

71A Plant Design and Construction. Brochure from Southwestern Engineering Co. describes their design, engineering, and construction facilities.

72L Corrosion-Resistant Linings and Coatings. Bulletins offered by Atlas Mineral Products Co. cover cements, linings, protective coatings, and rigid plastic structures.

73A Graphite Anodes. Great Lakes Carbon Corp. specializes in the production of graphite anodes for mercury cell application.

74L Heat Exchangers. Expert consulting services are offered by the Aerofin Corp. on heat exchanger design and specification.

75A Gas Generation Equipment. Gas Atmospheres, Inc. delivers completely unitized and factory tested generators for the production of industrial gases.

78L Positive Displacement Gas Pumps. R-C rotary gas pumps are made in 76 capacities and sizes. Capacities from 5 to 50,000 cu. ft./min. Bulletin from Roots-Connersville Blower.

79A Lithium Metal, Derivatives, Compounds. Lithium Corp. of America maintains representatives, sales offices, and warehouses throughout the United States.

80TL Scale Feeders. Merchen scale feeders offer continuous dry blending by weight. Booklet from Wallace & Tiernan, Inc.

80BL Chlorinators and Chemical Feeders. For slime elimination, water purification, and industrial waste and sewage treatment. Wallace & Tiernan, Inc.

(Continued on page 64)

PRODUCTS ADVERTISED IN THIS ISSUE (Cont.)

81A Impervious Graphite Products. National Carbon Co. offers bulletins and data sheets on activated carbon, carbon brick, and "Karbate" process equipment.

83A Water-Lubricated Submersible Pump. No line shafts, packing boxes, or lubrication devices required. Bulletin from Fairbanks-Morse.

84L High Alloy Castings. Duraloy Co. has had thirty-five years of experience in solving high alloy casting problems.

85A Non-lubricated Compressor Cylinders. Complete information on gas-engine compressors and non-lubricated compressor cylinders available from Ingersoll-Rand.

86L Viscosity Recorder. The "Viscometran," produced by Brookfield Engineering Laboratories, Inc., is used for end point determination and continuous "in-process" viscosity recording. Application data sheet.

87A Gas Separation Plants. Integrated design, manufacture, erection, and operation of plants for gas separation, liquefaction, and purification. Air Products, Inc.

88L 26th Exposition of Chemical Industries. Will be held at New York Coliseum, December 2-6, 1957.

89A Industrial Furnaces. More than 1,650 Petrochem "Isoflow" furnaces in operation or under construction since 1940. Petro-Chem Development Co.

92L Screening Equipment Catalog. Vibrating screens, test sieve shakers, packers and jolters, spiral feeders. Syntron Co.

93R Tube Mill Bulletin. For wet or dry grinding. From 2 to 10 ft. in diam., 6 to 35 ft. in length, with acid-proof lining of rubber, silica, and porcelain. Hardinge Co.

94L Filtration Catalog. Specifications and technical data on line of filter presses built by D. R. Sperry & Co.

95R Re-usable Couplings. Can be fitted without heat by a simple, clean mechanical process. Bulletins from Packless Metal Hose, Inc.

96L Mixing and Grinding Equipment. Double arm kneader, high speed three roller mill, several types of change can mixers. Details from Charles Ross & Son Co.

97A Continuous Reactors. Bulletin giving applications, operation, advantages, specifications of "Votator" continuous reactors available from the Girdler Co.

98L PVC Plastic Pipe Brochure. Detailed bulletin from Kraloy Plastic Pipe Co. describes their line of PVC process piping.

98BR Chemical Engineering Services. From process development and economic studies to definitive engineering designs. J. R. Minevitch and Associates.

99A Grinding Equipment. "Micronizers," made by Sturtevant Mill Co., grind and classify in single fluid-jet chamber, and provide fines in range from ½ to 44 microns. Technical literature.

100TL Metallic Raschig Rings. For difficult extraction processes involving the production of acids, oils, and dyes. Complete information from Metallo Gasket Co.

100BL Centrifugal Pump Data. Sizes from 1 to 10 in., heads to 250 ft., capacities to 4,000 gal./min. Nagle Pumps, Inc.

101A Super Centrifuge. For continuous clarification of liquids, separation of two immiscible liquids, removal of particles according to particle size. Demonstration test runs arranged. Sharples Corp.

102TL Flexible Hose Catalog. New industrial applications of "Flexaust" hose and "Portovent" retractable ducts. Flexaust Co.

102BL Welded Aluminum Tanks. Technical data from R. D. Cole Manufacturing Co. on tanks, pressure vessels, other processing equipment in aluminum, stainless and carbon steels, Monel, other alloys.

103BL Spray Nozzle Catalog. Complete technical information on line of advanced-design spray nozzles. Spraying Systems, Inc.

103R Water Supply Systems. Brochure from Ranney Method Water Supplies, Inc. describes their experience and facilities.

104TL Belt Feeder. The "Autoweightion," made by Thayer Scale Corp., provides continuous weighing of all materials from free-flowing to sticky.

104BL Spray Nozzle Catalog. Wide variety of nozzles in standard or special corrosion-resistant metals and materials. Binks Manufacturing Co.

105TR Heat Exchange and Process Equipment. Condensers, evaporators, mixers, reactors, pressure vessels, heat exchangers. Manning & Lewis Engineering Co.

105BR Single Disc Attrition Mill. Bulletins from Bauer Bros. Co. describe attrition mills, other types of grinding and pulverizing machinery.

108BL Flow Test Kit. Complete data and prices on compact, self-contained flow test kit. Ace Glass, Inc.

109TL Air Cooling Coil Bulletin. 2 to 15 ton capacity. Complete with multi-outlet expansion valves. Data and prices from Rempe Co.

109BL Pyrex Sight Glasses. Squares, rectangles, or odd shapes in 8 thicknesses, sizes up to 24 by 60 in. Swift Glass Division, Swift Lubricator Co.

109TR Gear Pump Bulletin. Bulletin from Schutte and Koerting Co. describes their line of gear pumps and gives details of their engineering services.

109BR Drum Reconditioning Machines. Complete equipment details and specifications from M. L. Gilbert Co.

110L Nickel-Bearing Alloy Fabrication. Design, development, fabrication of tanks, piping, pressure vessels, bubble towers, special equipment. Misco Fabricators, Inc.

111BL Thermocouple Wire. More than 1,500 different wire combinations. All standard calibrations and gage sizes. Thermo Electric Co.

111R Rotameters. The "Ar-Met" rotameter, made by Brooks Rotameter Co., features positive indication, all metal construction, through-bolted design. Bulletin.

118L Jet Ejectors. Brochure from Ingersoll-Rand gives technical data on their line of jet ejectors.

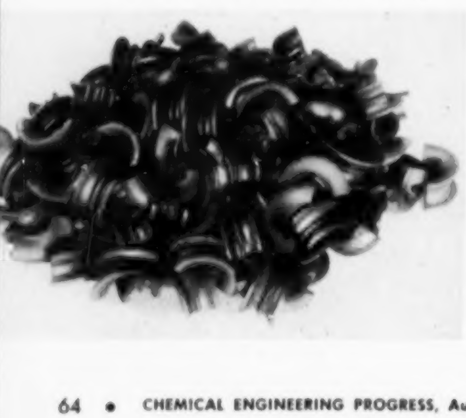
119BR Panel Coil Heaters. Can replace pipe coils in many processing applications. Bulletins with technical data, prices, from Dean Thermo-Panel Coil Division, Dean Products, Inc.

IBC Plant Design and Construction. Ralph M. Parsons Co. take special pains to guard confidential process data and know-how belonging to clients.

OBC Mixer Bulletins. Several brochures available from Mixing Equipment Co. on many types of mixing equipment.

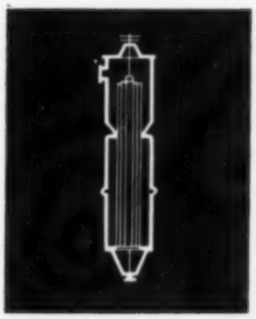
DEVELOPMENTS OF THE MONTH (Cont.)

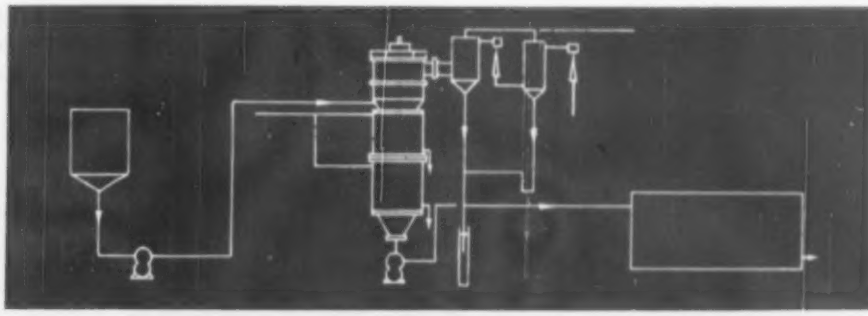
396 Carbon Tower Packing. Intalox saddle packing is now available in carbon from U. S. Stoneware Co. This new development is said to be the result of a joint research program of U. S. Stoneware and National Carbon Co.



At present these carbon packings are made in the 1 in. size only, but other sizes are to be made available shortly. They are particularly recommended for use in operations involving hot alkalis, mixtures of hydrofluoric and sulfuric acids, or hydrofluoric and phosphoric acids—applications where chemical ceramics would prove unsuitable. In addition, their low coefficient of thermal expansion enables them to be used under conditions of abrupt temperature change without danger of spalling.

Further technical information is available from the manufacturer. Circle number 396 on Data Post Card.





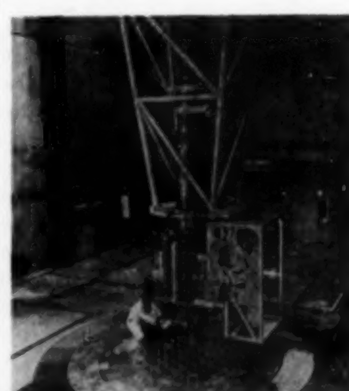
NUCLEAR NEWS

Release of information recently declassified on production of heavy water by the dual-temperature hydrogen exchange process continues to be held up by a restraining order issued to the A.E.C. by the U. S. District Court of Appeals in Washington, D. C. (*CEP* announced in May that an inventor named Spevack who claims patent rights to the process had initiated the action resulting in the restraining order.) As predicted in *CEP*, briefs were filed by attorneys representing both Spevack and the A.E.C. on May 28th. Presumably, the court would hand down its decision within a few weeks. At the time of writing, however, this has not happened and, as is the custom in such cases, no indication is available as to when such action will be taken. *CEP* will report on and comment further on developments as they occur. ☐

Cost of the Shippingport, Pa., reactor is said to be running far over original estimates, project completion will be delayed. Reason: unsatisfactory performance, particularly in corrosion resistance, of process equipment originally slated for job. ☐

Seven-hundred-hour performance test has been completed by Army on their Package Power Reactor at Fort Belvoir, Va. Shutdowns during test totalled only eight hours, generation of power exceeded design output. ☐

Operation has begun at the French nuclear testing reactor at Saclay. The unit, which uses heavy water made available by the U.S.A.E.C., went critical on July 9. ☐



Electric power was produced for the first time recently by heat from the Sodium Reactor Experiment during tests of the reactor and auxiliary components. Designed and built for AEC by Atomics International (North American Aviation), in the picture a huge, lead-shielded chamber for loading uranium fuel into the reactors hovers over the "core" of the reactor sunk deep beneath the ground.

Is your firm in the government's
SMALL BUSINESS CATEGORY?

Joseph L. Gillman, Jr.

—If so, Your Loan and Procurement Status May Be Changed by a new Legislative Action intended to Make The Size Yardstick More Realistic.

Congress has just passed a new law changing the definition of "small business." The new definition will rate size by a yardstick more equitable to the chemical industry than "number of employees."

Many manufacturers of chemicals and process plant equipment who have long enjoyed special privileges granted to small business may soon have their status changed to "big business." And some companies which have been handicapped by being classified as "big" may find themselves moved into the "small" category.

The rules for determining which companies are small and which are big for purposes of receiving loans and special procurement privileges under Public Law No. 163 are established by the Small Business Administration (SBA) which was created by the same law. SBA, for loan purposes, uses an industry-by-industry formula which will not be changed by the new law. But for procurement the rating basis differed. For consideration by Government procurement agencies, businesses were divided into big and small categories depending upon whether they had more or less than 500 employees regardless of the industry.*

* A company having more than 500 employees could sometimes, upon application, be granted a certificate declaring it to be "small" if SBA felt that its relative position in its industry justified the action.

Industry-by-Industry Favored

There was not much complaint over the industry-by-industry formula used for loan purposes. In such cases only two parties are involved—SBA and the applicant—and there are no dissenters. But when procurement came up, many or all of the losing bidders could be, and often were, complainers.

The new law makes mandatory the use of industry-by-industry comparative ratings for *both* loan and procurement.

The old law did not make mandatory the use of any specific criteria to define small business. It simply stated that SBA *could* use the number of employees and/or dollar volume as criteria, among others, after determining that the company was independently owned and operated and not dominant in its field.

That SBA has successfully used its industry-by-industry definition for making loans raises the question as to why the formula was not applied to procurement. One reason could be that the definition in use for loans comprises over five pages of fine print which might be awkward for use by the Government's vast procurement system.

Whatever the specific reasons, SBA has held steadfastly to its 500-employee rule for procurement and Congress had to step in, study the situation, and pass the new law.

Investigation

On October 30, 1956, a subcommittee appointed by the House made the following recommendations after investigation of the matter:

"1) The Small Business Administration discard its proposed definition as it applies to procurement;

2) The Small Business Administration immediately adopt an industry-by-industry definition in order that the same or a similar formula for defining small business will apply both to the financial assistance and procurement programs for small business;

3) All procurement agencies of the Government, particularly the Department of Defense, immediately proceed in good faith to effectuate such an industry-by-industry definition;

4) The Small Business Administration report to this committee by December 1, 1956, on the operation of a procurement definition based on an industry-by-industry breakdown pursuant to the recommendation of this committee."

On January 3, 1957, the Select Committee on Small Business made a final report to the House. One of the recommendations was: "That the Small Business Act of 1953, as amended, be further amended so as to direct the SBA to discard the numerical definition of "small business" now used for procurement purposes, and set up in lieu thereof an industry-by-industry definition in accordance with and subject to all provisions of the act."

On Aug. 2, 1957, H.R. 7963, providing for a separate act to be known as the Small Business Act and based substantially on the above recommendation, passed Congress. It was signed by the President on Aug. 3, 1957, and is now the new Small Business Law.

INSTITUTIONAL NEWS

Fulbright Awards are available this year in chemical engineering. There is an opening for a research scholar in chemical engineering at the University of Liege, Belgium. A lecturer is desired at the Univ. of Nancy in France, there will probably be openings in Germany, and Israel wants a visiting lecturer in chemical engineering to advise on the training of engineers for the rapidly expanding basic chemical industry of Israel. A visiting lecturer's position for instrumentation in chemical engineering is open at Yokohama National Univ. in Japan. Other openings are likely to become available and there are certain be requests for leading engineers to go abroad under the terms of the Smith-Mundt Act. □

New officers of the Chemical Institute of Canada are: O. J. Walker, Univ. of Alberta, pres.; C. E. Carson, Imperial Oil Ltd., vice-pres.; L. Piche, Univ. of Montreal, chmn. of the board; R. J. Allen, Canadian Titanium Pigments Ltd., treas.; G. T. Page, Chemical Inst. of Canada, general manager and secretary. □

The 12th Annual Instrument-Automation Conference and Exhibit is scheduled for Cleveland Auditorium, Cleveland, Ohio, September 9-13. Sponsored by the Instrument Society of America, the week-long program of conferences is one of the top events in the field of instrumentation and automatic controls. □

The Professional Engineers of Oregon will hold their convention at the Eugene Hotel, Eugene, Ore., October 18-19. □

A separate classification and pay schedule for engineers employed by the Federal Government has been recommended to a Senate subcommittee. Testifying before the Subcommittee on Federal Employees' Compensation, the National Society of Professional Engineers said: "An adjustment of the salaries of engineers and scientists in the Federal service is in order and is required if the Government is not to fall further behind in its effort to obtain and retain competent engineering staffs." □

INSTITUTIONAL NEWS

First Annual meeting of the American Association of Cost Engineers was held on the campus of the Univ. of New Hampshire. In addition to a technical program, the 161 members and guests present saw AACE president N. G. Bach present the association's Award of Merit to W. L. Nelson (left in picture), noted writer on cost engineering subjects.

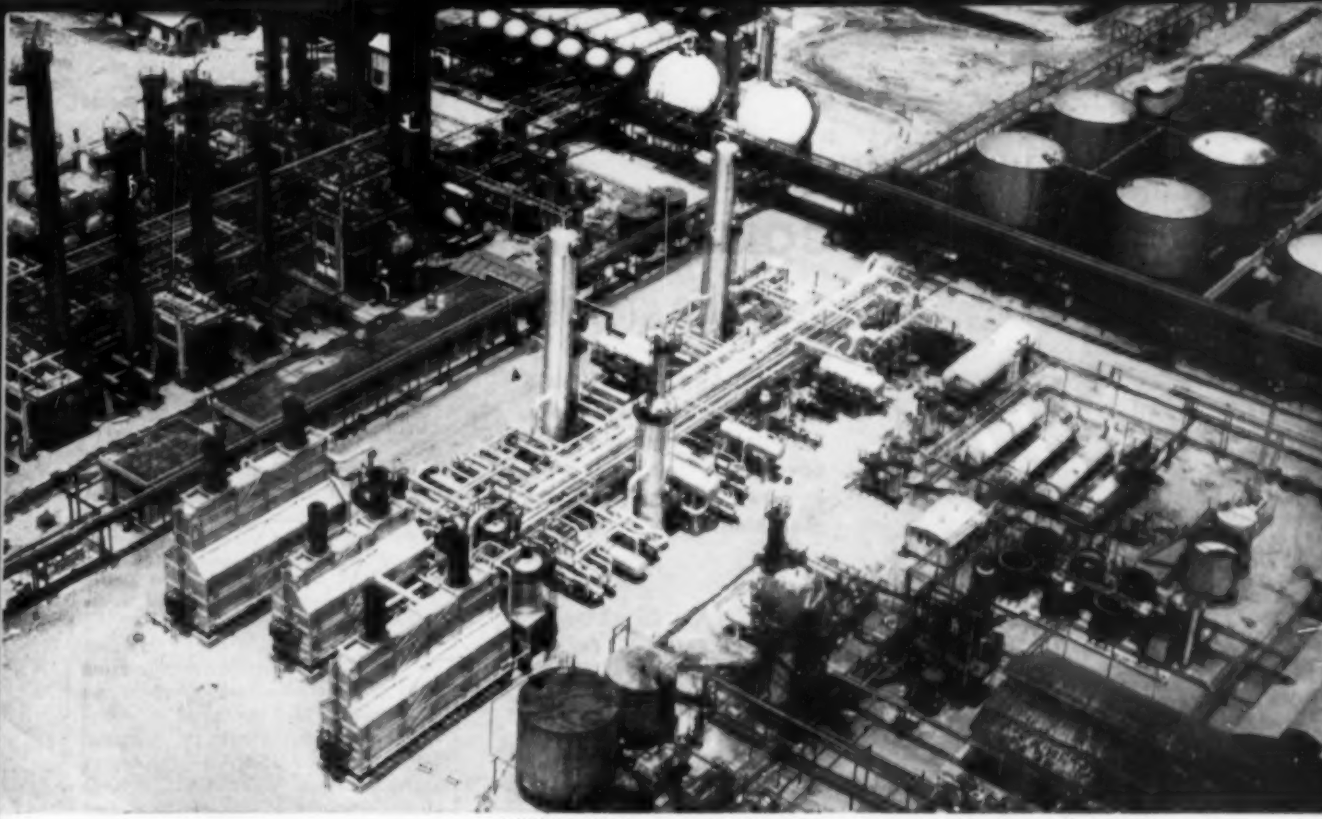
The first organizational step in the coordination of the activities of Enineers Joint Council and Engineers' Council for Professional Development will be the two-day Engineers General Assembly, a joint conference of the two organizations, to be held in New York's Statler Hotel, Oct. 24 and 25.

In a statement issued by J. W. Barker, president of EJC, and M. D. Hooven, president of ECPD, the two organizations point out that, "The joint program committee has developed an outstanding program that will reflect the common interests of the two organizations in the professional and social development of the engineer. The two groups have long recognized their closely parallel activities . . . this singularly important step is bringing together their annual meetings."

The program will consist of panel discussions on: Military Service as a Factor in Professional Development; The Community College in Technological Education; The Place of the Engineer in Industrial Management; and New Dimensions in Post-Graduate Education for Engineers. □

Site of the next International Conference on Peaceful Uses of Atomic Energy is as yet undetermined. Both Vienna and Chicago want it, Brussels, Geneva, and Paris may bid for it. But the location could depend on the Russians, according to experts. The Russians have not yet said if they want it held in Moscow. □

A record-breaking 650 metal scientists and engineers from more than 36 nations are expected to attend the 2nd World Metallurgical Congress to be held in Chicago November 2-8. □



Wilshire Oil Company of California's new catalytic reforming and desulfurizing units at Norwalk, designed and constructed by SWECO to produce high-octane motor fuel.

Teamed to Upgrade Lowgrade

Working together, Wilshire Oil Co. of California and SWECO have been solving process problems since 1923. They've done it again with this new 10,000 BPD Platformer-Unifiner for premium-quality gasoline.

To help satisfy the growing thirst of modern auto engines for higher octane fuels, Wilshire Oil Co. of California decided to add a new catalytic reforming unit at its Norwalk plant. Design and construction were placed in the hands of SWECO's Engineering and Construction Division. A logical choice. The two companies have been working together since 1923, when SWECO built an absorption plant for Wilshire at Santa Fe Springs. And for 34 years, SWECO had been supplying Wilshire with heat exchangers and other process equipment. SWECO was a known *dependable* quantity.

High temperature, high pressure

The Norwalk project was a 10,000 BPD Platformer-Unifiner to upgrade low-octane naphthas. Temperature and pressure requirements were high: The Platformer – using platinum as a catalyst to reform the molecular structure of hydrocarbons–required 975°F., 650 psig. The Unifiner – freeing sulfur from the naphtha to permit high-severity reforming – required 675°F., 850 psig. To meet process requirements, SWECO supplied 13 heat exchangers, designed and manufactured at its Los Angeles plant.

Signed, sealed and "on stream"

Approximately 13 months after SWECO engineers went to work, the Norwalk unit went "on stream." (Total elapsed time included 7 months of field construction.) It's a typical SWECO job. Done right, and done right on time, whether it's in Tanganyika, the Andes, or around the corner in Norwalk, California.

Typical also of SWECO teamwork on all jobs . . . in *engineering and construction* of refineries, chemical plants and ore beneficiating mills . . . in the design and manufacture of *process equipment* . . . in a complete line of *vibrating screen separators* . . . or *extended service* in plant modernization; procurement and expediting; plant operation.

For more information on how SWECO teamwork may help your engineering and construction needs, write for Brochure E-5-29.

SWECO

Southwestern Engineering Company

4800 Santa Fe Avenue, Los Angeles 58, California

Engineers and Constructors . . . Manufacturers

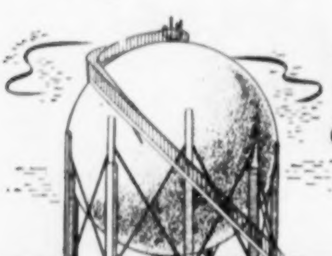
Cores for two nuclear reactors to be installed in West Germany are being fabricated at Atomics International (North American Aviation). One of the research reactors will be located at the Johann Wolfgang Goethe University in Frankfurt/Main, and the other at the Inst. of Nuclear Research, West Berlin. Both will be used for training and nuclear physics studies, scientific research, and for the production of radio-isotopes.

A contract to provide engineering data and technical assistance in the construction and operation of a styrene monomer plant at Ravenna, Italy, has been awarded to Koppers International, C.A., by ANIC, a large chemical firm of Milan. The new plant will have an annual rated capacity of 14,000 metric tons, the styrene will be used by ANIC to produce GR-S synthetic rubber. ☐

Work is in progress on a $33 million plus, 55,000 bbl. a day refinery for the Panama Refining & Petrochemical Co., Inc., of Panama City. The refinery is being built in Colon, Panama, by Foster Wheeler Corp. Target date for completion is less than two years. ☐

Five of the largest deep well vertical pumps ever built in the South are being shipped to Korea by their manufacturer, Johnstown Pump Co. of Pasadena, Calif., for use in a new power and fertilizer plant in the Chung-Ju area south of Seoul. The pumps, each of which can lift more than 50,000 gallons of water a minute 265 feet, were specially designed for the plant which is being built for the Korean Government by F. H. McGraw & Co. and Hydrocarbon Research, Inc., as an ICA project. ☐

A European Computation Center has been opened on Rue de la Science in Brussels, Belgium, by Electronic Associates, Inc., Long Branch, New Jersey. It is the first commercial facility of its kind in Europe, will emphasize analog computer techniques since EAI is the country's largest manufacturer of electronic analog computing equipment. ☐



OVERSEAS NEWS

Each year $50 million is contributed to the American chemical industry in the form of royalties for patents and "know-how" on the foreign licensing of chemical processes, according to R. S. Aries, New York consultant. At the same time growth of the chemical industries in Western Europe and in Japan has, during the last four years, outstripped the proportional growth of U. S. counterparts, aided as never before by private U. S. industry. □

Potasse & Engrais Chimiques has been awarded a contract by Societa Azienda Nationale Idrogenazione Combustibili of Milan, Italy, to erect a 400-600 ton a day complex fertilizer plant utilizing the PEC carbonitric process to produce a basic formula of 13-10-12 NPK. The PEC process, available from the Chemical and Industrial Corp., Cincinnati, in this country, was also used recently in a new plant built by C & I for California Spray Chemical Corp. □

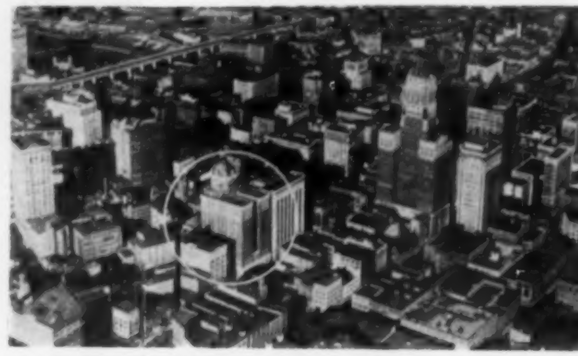
Four tons a day of technical grade DDT will be produced in a new plant at Alwaye, Southern India. Prime contractor is Singmaster & Breyer, New York. Contract supplier for the DDT-formulating unit of the plant will be Sturtevant Mill Co. of Boston, Mass. and Technical Enterprises of New York will act as process consultant. □

A new paint plant will be built in the new industrial section of San Jose de las Lajas about 25 miles southeast of Havana, Cuba, by Du Pont. The plant will be operated by Du Pont Inter-American Chemical Co., is expected to be on stream by September 1, 1958. □

A plant to produce plasticizers and synthetic resins located at Ruhle, West Germany, is the latest overseas project of Archer-Daniels-Midland Co. Its first unit already in production, the new plant was built in association with German and Netherlands interests, is being operated by Scado-Archer-Daniels GmbH & Co., which is owned by ADM and its German and Netherlands partners. □

High pressure polyethylene will be made and marketed in Italy by a new company, Celene, S.P.A., jointly-owned by Union Carbide Corp. and Societa Edison of Milan. Plans call for initial production of 24 million pounds. □

View of downtown Baltimore showing Lord Baltimore Hotel (encircled).



CHEMICAL ENGINEERS' WEEK IN MARYLAND

Gov. McKeldin has just proclaimed the week of A.I.Ch.E.'s National Meeting, September 15-18, as Chemical Engineers' Week in the State of Maryland in recognition of the vital role of chemical engineers in the nation today.

With this significant recognition by the State of Maryland, and a technical program designed to give the chemical engineer a lot to take back to his company, A.I.Ch.E.'s National Meeting in Baltimore promises to be one of the biggest to date.

Last minute highlights continue to pour in. The technical program features (see July *CEP* for full details) will include a big session on the present technology and economics of the chlor-alkali industry, and the chemical engineering details of Project Vanguard—rockets in outer space, with the chemical engineer helping to put them there. The whole expanding field of jet and rocket fuels will be presented, and the chemical engineering involved is far from being confined to fuels for rockets. Revolution is promised in the field of adsorption, dialysis and ion exchange, and if you are skeptical, come down to Baltimore and see for yourself. (We promise you ideas you'll take back to the boss post-haste.) Drying, low temperature processing, safety in ammonia and air plants, and that ever-present matter of operating costs in chemical processing plants will all be on the Baltimore program.

Banquet speaker on Tuesday will be Gov. McKeldin himself; his speech is still under wraps but promises to be a "big" one.

The Sunday panel session is now set. The subject, "Engineers Overseas, An Important Phase of a Post-War Trend," grows more important to the chemical engineer every day as American installations and technical assistance mushroom abroad. The panel members can now be named: Dr. Vittorio de Nora, Oronzio de Nora, Imbianti Elettrochimici, Milan, Italy; John J. Prichett, associate chemical director, Hilton-Davis Chemical Co., Cincinnati; John P. Ferris, special assistant to the Regional Director for Near East and South Asia, International Cooperation Administration; and George B. McGuire, Esso Research and Engineering Co. Being

KNOW YOUR SPEAKERS

SUNDAY Sept. 15 · de Nora · Prichett · Ferris · MONDAY Sept. 16 · Monet

Churchill · Fair · Mayers · Lane · Schatz · White · Greenhalgh · Johnson · Nott · Gen. Creasy

Clark · Gerlach · TUESDAY Sept. 17 · Marsel · Tormey · Major · Happel · Bloom · Brunsvold · Prutton

Haines · Wobus · Kirkham · McKelvey · Spiegler · Wylie · McKinley · Kurata · Swift · Christy

Walton · Peck · Christian · Kezios · Tourtellotte · Abelow · Flosdorf · Charlesworth · Marshall · Crosby

The General Committee for the Baltimore National Meeting of A.I.Ch.E. in September:
Front row, l. to r.: R. E. Hope, Chairman of the Sunday Panel Discussion on "Engineers Overseas, an Important Phase of a Post-War Trend"; R. L. Copson, Technical Program Chairman; Mrs. T. O. Tongue, Co-chairman, Ladies Committee; F. C. Hettinger, Executive Committee Chairman; Mrs. R. L. Copson, Co-chairman, Ladies Committee; and T. O. Tongue, Chairman, Finance Committee.
Back row, l. to r.: L. H. Brandt, Vice-chairman, Registration; W. K. O'Loughlin, Public Relations; W. H. Weed, Vice-chairman, Entertainment; A. Beerbower, Chairman, Student Activities; B. L. Harris, Vice-chairman, Executive Committee; S. R. Eckhaus, Chairman, Printing; E. W. Guernsey, Chairman, Public Relations; P. Messina, Vice-chairman, Arrangements; W. E. Eason, Jr., Program Copy; and R. E. James, Chairman, Plant Tours.

a chemical engineer overseas involves a lot more than you might think, has many pitfalls, different concepts, unusual working conditions. Any engineer who plans to, or hopes to, work abroad some day had better attend.

"The Role of the Chemical Engineer in the Industry-Defense Team" is the subject at the Monday luncheon. Speaker is the top man himself, Maj. Gen. W. M. Creasy, the army's chemical chief. Specific content of the general's speech is clearing security now, but he is going to talk about the areas where new ideas in chemical engineering are needed, how the engineer in industry can aid the engineer in the Defense Department.

The tremendous rate of growth of the chemical industry presents many problems management and the chemical engineer must solve, and quickly, if we are going to meet the staggering challenge of the future. Agreed? Well, Tuesday's luncheon speaker, C. F. Prutton, executive vice-president of Food Machinery & Chemical Corp., will show the importance of these problems, will give his views on just what we are going to have to do.

Cruise and Get-Acquainted

Not all work, though, at Baltimore. Final plans for the Monday evening cruise down beautiful Chesapeake Bay have been made. Cruise ship will

FOR YOUR WALLET

A.I.Ch.E. National Meeting, Baltimore, Maryland, The Lord Baltimore Hotel, Sept. 15-18.

Registration: begins Sunday, Sept. 15, 12 Noon, Mezzanine Floor of Lord Baltimore.

First Technical Session: 9:00 A.M. Monday.

Last Technical Session: 4:10 P.M. Wednesday.

Banquet: Tuesday, Sept. 17, 7:30 P.M., Calvert Ballroom, Lord Baltimore.

(Continued on page 78)

Graham Smith Hiltgren Juhola Baddour Geddes Griesmer Jones Lautensack Abbrecht

Selke Frisch McGarvey Vermeulen Maison Hancher Jury Zabel Sheets MacMullin

Winger Kammermayer Lane Riggle Henderson Sliepcevich Mason Juda Maune Gropper

Heckes Aronson Harnish Hopkins Sept. 18 Burghardt Harris Little Strunk Dougherty

Thomas Mecredy Gilliland Brian Schumacher Stern Ebach Strom Kintner Copson

BALTIMORE

(Continued from page 77)

The Francis Scott Key monument is one of the many in Baltimore which help to earn it the sobriquet "Monumental City."

leave from the heart of the city at 6:10, will pass close by historic Ft. McHenry, will make a close-in tour of Baltimore's chemical industry while you lounge in comfort on deck. And Chesapeake Bay Bridge is one sight you won't want to miss. There'll be a buffet supper, with crab involved of course, and this is your chance to dance under a southern moon!

New feature: The Sunday Get-Acquainted Party (5:30 to 7:30) will have a "wandering minstrel" to entertain you—if you can stop talking to old friends and associates long enough!

A bonus this trip is the Tuesday cocktail party of the Baltimore Professional Chapter of Alpha Chi Sigma (Professional Chemical Fraternity) held at 5:30. All engineers and their ladies attending the meeting are invited—it should be a first-rate chance to get to know the chemical industry men of Baltimore, ask questions, get answers. (And have a very pleasant evening, too.)

Plant Trips: Don't forget them—they're a feature at Baltimore. Full details were given in the July *CEP*.

NEW MEMBERS—NEW ATTENDEES—ATTENTION!!

(Old members and attendees, too!) The local committee at this meeting has come up with a unique plan to help new members and first-time National Meeting attendees to "get to know" their fellow Institute members. It's a special room—The Founder's Room of the Lord Baltimore Hotel—which will be open throughout the meeting for the benefit of all members who wish to have a place to meet their soon-to-be friends.

FUTURE MEETINGS

The 8-mile long $50 million Chesapeake Bay Bridge near Baltimore is a connecting link in the growing Atlantic Coast expressway system.

MEETINGS **SYMPOSIA**

■ BALTIMORE, MD.

September 15-18, 1957. Lord Baltimore Hotel. See story on page 76. Complete program was published in last month's CEP.

Adsorption, Dialysis, and Ion Exchange

Intended to furnish basic information for chemical engineers working on mass separation problems.

Jet Propulsion

Emphasis will be on manufacture of chemical fuels. One paper on application to Earth Satellite program.

The Alkali-Chlorine Industry

A management symposium on technological problems, trends, and end uses.

Drying

Aspects of industrial drying, including spray drying techniques.

Low Temperature Processing

The second symposium on this subject following an introductory session at the last Boston meeting.

Direct Operating Labor Costs

Featuring an industrial engineering approach to estimation of labor costs.

Air Plant Safety

A panel discussion with a planned agenda.

Ammonia Plant Safety

A panel discussion with a planned agenda.

■ CLEVELAND, OHIO

September 7-13, 1957, Cleveland Auditorium. Annual Instrument Automation Conference & Exhibit of the Instrument Society of America. Conference theme will be "Instrumentation for Systems Control." About 500 individual exhibits will depict latest developments in the field. About 100 papers will be presented followed by informal discussions. Exhibit will be open Monday, Sept. 9, 2-10 P.M.; Tuesday, Sept. 11, 10 A.M.-6 P.M.; Wednesday, Sept. 11, 10 A.M.-6 P.M.; Thursday, Sept. 12, Noon-10 P.M.; Friday, Sept. 13, 10 A.M.-4 P.M.

Clinic sessions over weekend preceding exhibit. A.I.Ch.E. members are invited to register at same rate as ISA members.

(Continued on page 86)

under field test in the chemical industry:

LOW-NICKEL STAINLESS STEELS

J. G. Henderson *

An extensive corrosion testing program is now underway throughout the chemical industry to determine the effect of manganese as a partial replacement for nickel in stainless steels intended for anti-corrosive service. Particular attention is being focused on evaluating comparatively the general corrosion resistance of A.I.S.I. Type 202, which has been in limited commercial production for some time, with that of Type 304. The complete success of the program, however, depends on attracting even more participating companies than are presently involved.

The program is cooperatively sponsored by the Chemical Industry Advisory Board of the American Standards Association, the American Iron and Steel Institute, and the International Nickel Co., the latter handling all aspects of sample preparation and distribution as well as the tabulation and correlation of data.

In Peacetime—Not a Substitute Material

While the motivating force which originally set the program on the road was undoubtedly the drastic nickel shortage during and immediately following the Korean War, it is now felt that these materials must be viewed not as substitutes for higher-nickel stainless steels but in their own right. Barring a national emergency, reliable forecasts indicate that nickel should be in adequate supply within a very few years (see Table 1). The use of the 200 Series steels in peacetime must be predicated on their desirable properties and on their comparative economics. However, since determinations of the adequacy of materials for corrosive service, particularly in the chemical industry, is often a matter of years, the results of the program may serve to provide the chemical industry, under peacetime conditions, with valuable information regarding the usefulness of these materials as a conservation measure in an emergency.

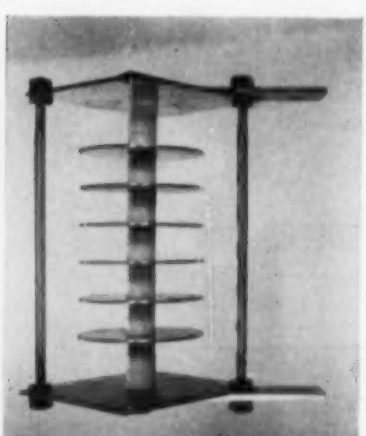
How to Participate

All chemical companies not yet involved in this program are urged to lend their assistance. Test spools along with instructions for their use may be obtained from W. Z. Friend, Corrosion Engineering Section, Development and Research Division, International Nickel Co., Inc., 67 Wall Street, New York 5, N. Y.

The corrosion test spools for this program (Figure 1) contain two specimens of each of two different heats of Type 202 (from two different producers) and two specimens of one heat of Type 304 for purposes of comparison. Spools are shipped fully assembled ready to be placed in test. Each test spool has been cleaned and weighed to the nearest 0.1 milligram. Specimens are fully insulated from each

(*Continued on page* 84)

* Mr. Henderson is chairman of the Chemical Industry Advisory Board, American Standards Association.



Typical test spool being used in the corrosion testing program.

Table 1.—Expected Additions to World Nickel Supply

1. Increase in Cuban supply (Nicaro) from 30,000,000 to 50,000,000 lb./yr.
2. Falconbridge to expand production to 50,000,000 lb./yr.
3. Freeport Sulphur Co. to produce 50,000,000 lb./yr. from Cuban ore (Moa Bay).
4. French Nickel Co. in New Caledonia to increase production from 20,000,000 to 44,000,000 lb./yr.
5. International Nickel Co. to increase production by 100,000,000 lb./yr. by development of Moak Lake area (Manitoba).

COOPERATIVE EFFORT

In September, 1955, the Chemical Industry Advisory Board of the American Standards Association instituted a nickel conservation program directed not only at the chemical industry but also at other nickel consuming industries. Basic purposes of the program were:

- To alert the chemical industry to the seriousness of the situation and to urge the use of low-nickel and nickel-free stainless alloys in all cases where they might be substituted for the higher-nickel alloys. The existence of A.I.S.I. Types 201 and 202 austenitic stainless steels was brought to the attention of the chemical industry, and technical data on these steels was made available to various companies throughout the industry. Since very little actual experience data was then available on these materials, the C.I.A.B. offered to establish an evaluation program within the industry, and to act as a clearinghouse for all information that might develop from the evaluation program.
- An outline of the chemical industry program was transmitted to other non-defense nickel consumers, with the suggestion that they also initiate similar programs within their respective industries.

Letters outlining the program and asking for support were sent by the C.I.A.B. on January 2, 1956, addressed to some 150 chemical companies, and on March 7, 1956, addressed to a broad section of other important nickel-consuming industries.

Initial response to the program from the chemical industry was most encouraging. Some 60 companies immediately indicated a desire and a willingness to participate. A joint meeting (May, 1956) between C.I.A.B. representatives and members of the Tubular Products and Stainless Steel Technical Committees of the A.I.S.I. took positive steps to implement the program. With the cooperation and assistance of the International Nickel Co., a broad testing program is now being carried forward in the chemical industry to determine the serviceability of Type 202 under corrosive conditions. Three steel companies supplied special heats of experimental stainless steels and the International Nickel Co. prepared samples and test spools for distribution. Service testing is now underway and evaluation of data is expected to start shortly. Detailed results will be made available throughout the chemical industry.

Table 2.—Compositions of the Various Cr-Mn-Ni and Cr-Mn-N Stainless Steels

Type	Max. C	Mn	Cr	Ni	Max. N_2
201 *	.15	5.5–7.5	16–18	3.5–5.5	.25
202 *	.15	7.5–10	17–19	4–6	.25
16–16–1 (TRC)(CM)	.15	13.0–18.0	14–17	1.0	.25
U.S.S. Tenelon	.10	14.50	17	......	.40 †
204	.10	7.5–10	17–19	4–6	.25
204L	.06	7.5–10	17–19	4–6	.25
20–6–8	.10	7–9	19–21	5–7	.35

* These are the only A.I.S.I. grades. † Need not be maximum.

STAINLESS STEELS

(*Continued from page 82*)

other with either Teflon or Bakelite as required by test exposure conditions. Structural parts of the spools are Type 316 stainless throughout.

The company receiving the spool need simply install it in the equipment in question according to the recommendations. Length of exposure will generally vary from 60 to 90 days; this time, however, may be varied to permit removal of the spool when the equipment is down for maintenance. With each spool there will be provided a "Record of Corrosion Test Exposure" to be returned with the spool at the end of the test.

Upon receipt at Inco's Wrightsville Beach-Harbor Island, N. C., Testing Station, the spools will be disassembled, the specimens cleaned and reweighed, and corrosion rates determined. They will also be examined carefully for evidence of pitting, crevice corrosion, cracking, or other forms of localized attack. A full report of these observations will be made for each individual spool, and a copy of the report will be furnished to the company conducting the test.

Low-nickel Stainless Steels

By about 1950, studies of the various austenitic steels (see Table 2) produced over the years indicated that a minimum of 3.5 to 4% nickel would probably be required in an alloy which could be expected to approach or match the corrosion resistance of the 300 Series alloys. Chromium is the element which confers stainless characteristics on iron and the corrosion resistance of a stainless steel is in general proportional to its chromium content. Experience had shown that, with 1% nickel and high manganese, only about 15.5% chromium could be added and still maintain an austenitic structure.

To increase the chromium content for improved corrosion resistance in the substantial absence of nickel, some alteration had to be made in composition. It was found that nitrogen in high amounts will accomplish this purpose and that, when the nitrogen is in the range of 0.30 to 0.70%, the chromium content can be raised appreciably. Steel of this composition has promising strength properties but, due to the absence of nickel, it is probably inferior in corrosion resisting properties to the chromium-nickel steels for many corrosive environments.

As the nickel content is increased, however, greater amounts of chromium can be taken into solution without resulting in a duplex structure. Thus, with 3.5% nickel in a manganese-modified steel, about 17% chromium can be accommodated, and corrosion resistance in some environments approaches that of the 18-8 steels. This, then, is the pattern of reasoning which resulted in expanded commercial production of the 200 Series stainless steels.

FUTURE MEETINGS

(*Continued from page* 80)

WASHINGTON, D. C.

September 18-20, 1957, National Bureau of Standards.

Symposium on **Formation and Stabilization of Free Radicals.** Sponsors: U. of Maryland, Catholic U. of America, Johns Hopkins U., National Bureau of Standards. Discussions of current research on the properties of systems containing trapped atoms and radicals.

CHAIRMAN: A. M. Bass, Free Radicals Research Section, National Bureau of Standards, Washington 25, D. C.

ATLANTIC CITY, NEW JERSEY

October 16-18, 1957, Chalfonte-Haddon Hall Hotel. Conference on **Computers in Control.** Sponsored by A.I.E.E. with participation by I.R.E. and A.S.M.E. About 35 technical papers by leading scientists in this country and abroad.

NEW YORK, N. Y.

October 28-November 1, 1957, New York Coliseum and Henry Hudson Hotel, Plaza Hotel, and Waldorf-Astoria Hotel.

International Atom Week. Trade fair and series of conferences and meetings sponsored by Atomic Industrial Forum, American Nuclear Society, Institute of Radio Engineers, and the A.E.C.

ANNUAL—CHICAGO, ILL.

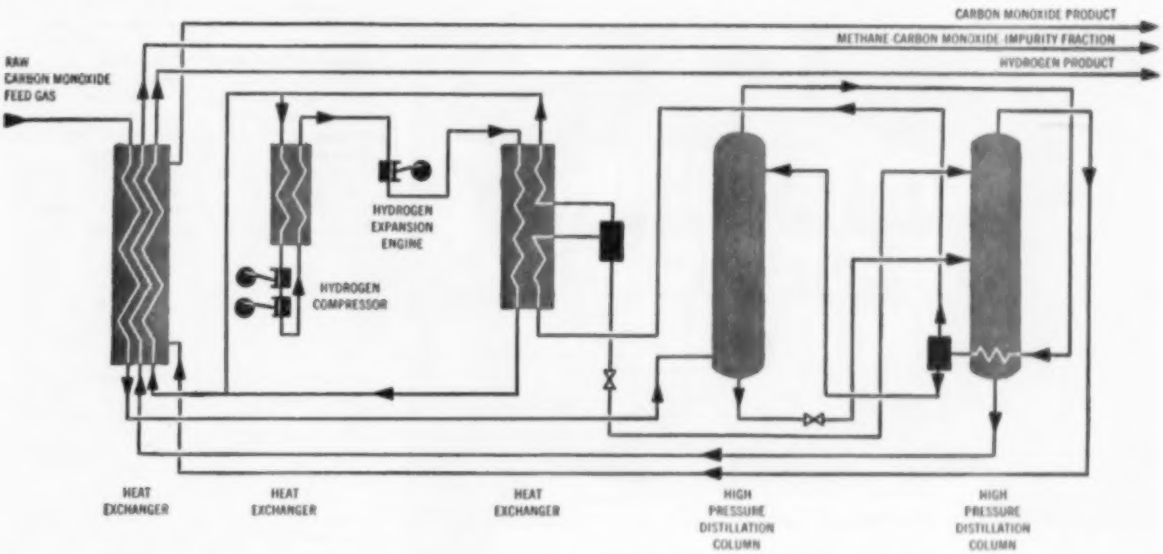
December 8-11, 1957. Conrad Hilton Hotel.

TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind.

Latest news from technical program chairman **Hank Nolting** on Chicago Meeting details: . . . **Gilliland's** basic **Fluidization** symposium rounding into final form, will offer solid theoretical background. . . . **Effective Cost Control** session, headed by **Nofsinger** and **Fisher,** to delve into reasons behind today's lower profit margins and possible remedies. . . . **Nofsinger's** symposium on **Project Evaluation** will stress "techniques used for continuous evaluation of projects—from inception of the idea through construction of commercial facilities—considered as essential for earliest realization of profits, maximum return on investment, and timely discontinuance of unprofitable projects" . . . According to **Shelby Miller,** who leads **Chemical Engineering Abroad,** his session will cover both educational and industrial aspects of chemical engineering in Russia, Great Britain, France, Italy, and Germany. . . . **Corrosion Resistant Materials of Construction,** under **G. Fred Ours,** promises to unlock many doors for those involved in corrosion problems—and what chemical engineer isn't? . . . New approach to pilot plant operation will be used in **Laboratory and Pilot Plant Techniques.** Morning session (**G. W. Blum,** Goodyear) will be "a primary consideration of economic planning of pilot plant programs," afternoon session (**J. M. Cummings,** Fenn College) "will examine the problems encountered in specific case histories, or in new types of equipment" . . . No report as yet on legal controversy raised by proposed **Heavy Water Production** symposium, chairman **W. P. Bebbington.** . . . **Joe Martin's** session on **Radiation Processing** coincides with a wave of industrial interest in the potentialities of this new tool. . . . **Nuclear Process Heat,** under **B. W. Gamson,** is another frontier which may become vital to the chemical engineer. . . . **Gamson** will also head **Extractive Metallurgy,** a field which is becoming more and more the domain of

(*Continued on page* 88)

A new approach to production and purification of carbon monoxide from crude synthesis gas



In the production and final purification of carbon monoxide from crude synthesis gas, low-temperature processing plays an important part. Synthesis gas—produced by steam reforming or various partial oxidations—contains CO, H_2 and some carbon dioxide. From this composition, it is possible to recover up to 95% of the CO, as a product of up to 99.5% purity, using low-temperature equipment designed and built by Air Products, Incorporated.

Air Products carbon monoxide purification plants feature:

. . . high-purity carbon monoxide and hydrogen product streams
. . . maximum recoveries—higher capital return
. . . automatic control—minimum labor requirements
. . . low power consumption
. . . factory assembled plants—with low installation expense

Low-temperature processing is not limited to just this type of gas purification. Designs are available and plants have already been built for such processes as . . . recovery of helium and nitrogen, separately, from natural gas . . . purification of methane . . . recovery of pure hydrogen from cracked petroleum off-gas streams. New processes are constantly being developed, and can be tailored to your needs.

Integrated design, manufacture, erection and operation of Air Products plants makes possible guaranteed results . . . for gas separation, liquefaction and purification systems. Plants are built to customer specifications. Ask us how low-temperature processing can be put to work for you. Your inquiry is invited. Air Products, Incorporated, P.O. Box 538, Allentown, Pa.

Air Products
. . . INCORPORATED

FUTURE MEETINGS

(Continued from page 86)

the chemical engineer. . . . How do you sell your ideas to your own management? **Selling a Technical Program** (**Dennis Murphy**) may give you the answer. . . . "Papers already submitted for the symposium on **Shock Waves in Process Equipment,**" says chairman **Stuart Churchill,** "discuss conditions for the formation of detonations, shock waves, potential impact pressures, behavior of equipment and materials under impulsive loading, criteria for design and operation, and a case history of the detonative failure of a large refinery processing unit" . . . Papers in the session on **Impact of Computers** will describe "results of computer work on problems such as multi-component, multi-column distillation and refinery economics," says chairman **Leon Cooper.** New co-chairman of this session is **Chen-Jung Huang,** Univ. of Houston. . . . Latest techniques for separating and recovering materials in biological processes to be theme of **Separation of Materials in Biological Processes,** chairman **Elmer Gaden.** Special operations about which little is known outside of the pharmaceutical companies involved include separation by continuous electrophoresis, ion-exchange membranes for purification of organic electrolytes, foam separations in protein solutions. Added feature will be recovery of antibiotics on commercial scale. . . . **Chemicals Recovery** in the **Paper Industry** under **R. P. Whitney** to emphasize possibility of profitable by-product recovery.

■ 1958 MEETINGS

• Chicago, Ill., March 17-21, 1958.
1958 Nuclear Congress. Managed by A.I.Ch.E. Coordinated by E.J.C. Will include: 4th Nuclear Engineering and Science Conference, 4th International Atomic Exposition, 6th Atomic Energy in Industry Conference, 6th Hot Laboratories and Equipment Conference, and the American Power Conference.

• Montreal, Canada, April 20-23, 1958. Sheraton-Royal Hotel. Joint A.I.Ch.E.-C.I.C. Conference. A.I.Ch.E. CHAIRMAN: Kenneth Beatty, North Carolina State College, Raleigh, N. C. CO-CHAIRMAN: W. H. Gauvin, McGill University, Montreal. **Chemical Engineering Aspects of Heavy Water Power Reactors**—CHAIRMAN: Donald Stuart, Evaluation Section, Civilian Power Reactors Branch, A.E.C., Washington 25, D. C.

• Philadelphia, Pa. June 22-27, 1958. Bellevue-Stratford Hotel. A.I.Ch.E. Fiftieth Anniversary Meeting. CHAIRMAN: Roy Kinckiner, DuPont, Wilmington, Del. Theme for program is: **A Look to the Future.** All symposia and papers are being planned in accordance with this theme.

• August 18-21, 1958. A.I.Ch.E.-A.S.M.E. Heat Transfer Conference. CHAIRMAN: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.

• Salt Lake City, Utah, September 21-24, 1958. CHAIRMAN: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City. **Air Pollution**—CHAIRMAN: W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California. **What's New in Liquid Metals Technology**—CHAIRMAN: Marshall Sittig, American Lithium Institute, Inc., P. O. Box 549, Princeton, N. J.

• Cincinnati, Ohio, December 7-19, 1958. Netherland Plaza Hotel. A.I.Ch.E. Annual Meeting. TECHNICAL PROGRAM CHAIRMAN: A. C. Brown, Emery Industries, Inc., June & Long

(Continued on page 92)

you can judge

the comparative values of furnace design

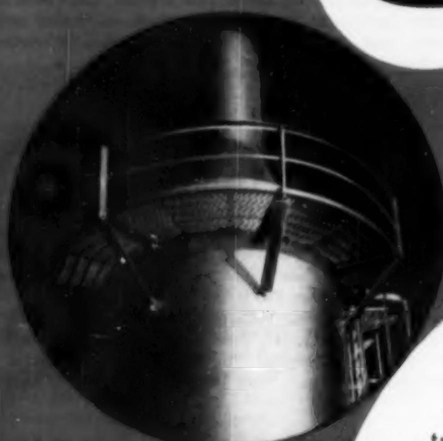
as applied to operating requirements.

It's quite simple

there are 9 basic factors

which must be evaluated

to obtain the full comparison of values



1—Average radiant transfer rate. 2—Maximum deviation from average radiant transfer rate. 3—Average and maximum transfer rate in convection section. 4—Maximum tube wall temperature, radiant or convection. 5—Maximum efficiency with specified excess air. 6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube. 7—Overload and corresponding transfer load. 8—Design to provide: structural column supports · Ladders · Platforms · Tube Removal facilities, etc. 9—Degree of assembly; of the furnace structure and of the heating surface.

Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.

No other furnace design can claim the recognition and acceptance achieved by PETROCHEM ISOFLOW FURNACES . . . starting with one installation in 1940, January '57 records more than 1650 ISOFLOW FURNACES in operation and under construction—a record that is incomparable just as all Petrochem Isoflow furnaces are more economically desirable by any comparison.

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Candidates for A.I.Ch.E. Offices

Here are brief biographical sketches of candidates for Fall 1957 A.I.Ch.E. elections. Candidates are chosen by the Nominating Committee unless otherwise designated as nominated by petition. Additional details on each candidate's education and career are available upon request from the Secretary's Office. Further nominations by petition may be received until October 7, and any so received will be announced with brief biographical sketches in the next available issue of C.E.P. Ballots will be mailed from the Secretary's Office in October. It is recommended that members check the October issue of C.E.P. for last-minute petition-nominee announcements.

OFFICERS FOR 1958:

- **PRESIDENT**

GEORGE E. HOLBROOK—Industrial executive. General mgr., Elastomer Chemicals Dept., Du Pont ('57-); Organic Chem. Dept. ('55-'57); Head, New Prods. Div. ('38); asst. dir. Jackson Laboratory ('43); gen'l. supt. Development, Chambers Works ('49); asst. dir. Tech. Div., Organic Chem. Dept. ('49); departmental engr. ('49); mgr. Chambers Development Sect. ('50); asst. dir. Devel. Dept. ('50). Dir. Chemical Div., Nat'l Produc. Authority ('52). Author numerous articles, patents on organic chemicals. A.I.Ch.E. Dir. ('50-'52); Chmn. Pub. Comm. ('55-'57); mbr. **C.E.P.** Adv. Board; Chmn. Program Comm. ('48-'50), mbr. ('45-'50); Chmn. Future of Inst. Comm. ('53-'55); Mbr. Awards Comm. ('54-'55). Offices in Phila.-Wilm. Sect. Prof. Progress Award ('53).

- **VICE-PRESIDENT**

DONALD L. KATZ—Educator and consultant. Prof. and chmn. dept. of chem. & metall. engrg. Univ. Michigan. Res. engr. ('33-'36) Phillips Petrol.; asst. prof. ('36-'42); assoc. ('42-'43); prof. ('43-); chmn. dept. ('51-) Univ. Michigan. Consulting engr. to some 30 companies, assoc. & govt. agencies. A.I.Ch.E.: Dir. ('54-'57); chmn. ('53-'54) exec. comm.; Nuclear Engrg. Div. ('55) tech. program chmn. Ann Arbor Nuclear Congress ('54) secy. gen'l. comm. & program chmn. Cleveland Nuclear Congress ('55) co-chmn. heat transfer symposia ('51, '53). Committees: Publications ('53-); Program ('45-); Chem. Engrg. Educ. & Accred. ('53-); Nucl. engrg. ('52, chmn. '53); Judging Presentations (chmn. '50-'52); Student Chapter ('43-'50, secy. '47, chmn. '48-'49). Counselor U. Mich. student chptr. ('38-'41). Co-author "Unit Operations," "Natural Gasoline & Volatile Hydrocarbons," "Fluid Mechanics & Ht. Tr.," "Nat'l Gas Engrg."

WALTER E. LOBO—Industrial Executive. Dir., res. & devel., M. W. Kellogg. Dir. Chem. Eng. Div. ('39-), other engrg. & superv. capacities ('29-'39); Columbia Univ. lecturer ('39-'41); Tech. cons. N.D.R.C. ('44-'46); Cons. Army Chem. Corps ('56-). Author heat transfer, furnaces, distillation, tonnage oxygen, process design. A.I.Ch.E. Dir. ('55-'57); Chmn. Progr. Comm. ('50-'52); Chmn. Res. Comm. ('51-'54); Chmn. Const. & By-Laws Comm. ('56-'57); Awards Comm. ('48-'51); Publ. Comm. ('46-'52); Jersey Sec. Progr. Comm. Chmn. ('49); E.J.C. Dir. ('55-'57), Chmn. Fin. Comm. ('56-'57); Chmn. Gov't Act. Comm. ('57); Mem. Const. & By-Laws Comm. ('56-'57); Intl. Rel. Comm. ('56-'57); A.I.Ch.E. repr. United Eng. Trustees.

- **SECRETARY**

F. J. VAN ANTWERPEN—Professional society executive, publisher, editor. A.I.Ch.E.: Secretary & executive secretary ('55-); publisher, bus. mgr. ('46-); editor **CEP** ('47-'55). Mr. Van Antwerpen's election to secretaryship augmented a long history of service to the Institute. Through **CEP**, Symposium & Monograph Series, and more recently A.I.Ch.E. Journal, he has been prime instigator in expansion of publication services to members of the profession. A founder of a major local section, he is active on many committees working within the Institute with A.E.C., A.S.A., and other groups. He has long been a force in E.J.C. and E.C.P.D. affairs and is one of the leading proponents of professional recognition for chemical engineers.

- **TREASURER**

J. HENRY RUSHTON—Educator, consultant, President of A.I.Ch.E., Prof. chem. engrg. ('55-), Purdue; consultant, Dept. of Defense, A.E.C., firms in petrol. & food indust.; tech. advisor, Mixing Equip. Co.; Prof. & dept. head ('37-'46), U. of Va.; prof. & dir. of dept. ('46-'55), Ill. Inst. Tech. Author: mixing, scale-up, low-temp. operations, others. A.I.Ch.E.: President ('57), vice-pres. ('56), Dir. ('52-'54); chmn. Local Sect. Activ. Comm.; has been chmn. Student Chapters, Projects, Future of Inst. Comms. Chicago Sect. dir. ('52-'55). Walker Award ('52). Mbr.: A.S.E.E. (past mbr. Council, secy. ad hoc Comm. on Eval. Engrg. Educ.); E.C.P.D. (mbr. Educ. & Accred. Comm.); N. Y. Chemists' Club (past non-res. v.p., active '54-'56).

DIRECTORS—FOR THREE-YEAR TERMS BEGINNING 1958:

NOMINATED BY COMMITTEE

R. P. GENEREAUX—Industrial executive. Mbr. ('51-), administrative staff Engrg. Dept., Du Pont. Res. chem. engr. ('29-'36), chem. plant design ('36-'38), supv. chem. engrg. res. ('38-'40), project mgr. incl. Hanford ('40-'44), supv. of engrg. design ('44-'47), asst. mgr. Des. Div. ('47-'49), mgr. Engrg. Service Div. Du Pont Co. ('49-'51). A.I.Ch.E.: Chmn. ('55), executive comm. ('56-'57), Nuclear Engrg. Div. Nominating comm. ('56); A.I.Ch.E. representative on Nuclear Stds. Bd. ('56-), Comm. B-31 (-'54), A.S.A.; chmn. Phila.-Wilm. Section ('46); mbr. Student Contest Prob. Comm., ('39).

L. C. KEMP, JR.—Industrial executive. v.p. petrochemicals, The Texas Co. Chem. engr. ('29-'40) at Texaco's Port Arthur inst.; asst. supt. res. ('40-'41) at Beacon labs; dir. res. & asst. mgr. tech. & res. div. ('41-'53), assistant to v.p. refining ('53-'54), asst. to sr. v.p. ('54-'55), genl. mgr. Petrochemical Dept. ('55-'57), v.p. ('57-) at Texaco's New York offices. A.I.Ch.E. Repres. to U.E.T., & to E.J.C. Comm. on Employ. Conditions (vice-chmn. '56-). Mbr. Pollution Control ('56-), Admissions chmn. ('52-'53), Housing ('56-'57) comms. Various comms. N. Y. local section.

JOHN J. McKETTA—Educator. Prof. & chmn. Dept. of Chem. Engrg., Univ. of Texas. Asst. div. supt. ('37-'40) Wyandotte; chem. dir. ('41-'42) C. B. Schneible Co.; fellow, instruc. ('42-'45) Univ. Mich.; asst. prof., prof. ('46-'52), chmn. dept. ('50-'52, '55-), grad. prof. ('54-) Univ. Texas. A.I.Ch.E.: Comm.—chmn. ('55-), vice-chmn. ('54-'55) mbrshp; Sym. & Nomen. ('55-), Accrediting ('52-), genl. chmn. Ann. Mtg. ('52), chmn. Prog. Ann. Mtg. ('50). Regional—Schol. ('56-), Past Pres. ('55-), Exec. ('51-'55), chmn. ('54) chmn.-elec. ('53) So. Texas.

HENRY F. NOLTING—Industrial executive. Dept. hd., ('48-) Mfg., Stand. Oil (Indiana). Chem engr. ('39) Union Oil; ('39-'40) Ashland Oil; ('40-'41) Hercules; ('41-'42), tech. asst. to asst. genl. mgr. mfg. ('42-'43), group ldr. tech. service ('43-'46), asst. dept. head ('46-'48), dept. head, Mfg. ('48-). A.I.Ch.E.—Program chmn. Chicago ann. mtg. ('57); Comm.—Program ('56-), Equip. testing proc. ('55-), Inst. Sect. ('56), Nominating ('57). Publ. on lubricating oil mfg.

E. R. GILLILAND—Educator & consultant. Prof. of chem. engrg., M.I.T. Instruc. ('34-'36), asst. prof. ('36-'39), assoc. ('39-'44), prof. ('44-), deputy dean engrg. ('45-'46), chmn. faculty ('52-'54), acting head, chem. engrg. dept. ('51-'53, '55-'56), M.I.T. Asst. Rubber dir. chg. res. & devel., Office Rubber Dir. ('42-'44); deputy chmn. Div. 11, N.D.R.C. ('44-'45); deputy chmn. Jt. Chfs. Staff, guided missile comm. ('45-'46); vice-chmn. fuels & lubs. subcom. N.A.C.A. ('46-'47); guided missiles comm., Jt. Res. & Devel. Bd. ('48-'50), consul. Brookhaven, ('47-'55). Walker ('54), Prof. Progr. ('50) awards.

S. L. LOPATA—Industrial executive. Pres. Carboline Co. div. Mullins Non-Ferrous Castings Corp.; partner, Process Engrg. & Equip. Co. Chem. engr. devel. ('35-'37) Cellulose Res. Corp. div. Olin Indus.; chem. engr. ('37-'38) Clinton Indus. Tech. service, sales ('38-45) Duriron Co. Founder ('45) Carboline Co. corrosion-resistant coatings application (pres. '45-) and Process Engrg. & Equip Co. (partner '45-). A.I.Ch.E. activities: Local Sections Comm. (mbr. '53-'56, Chmn. '55-'56); St. Louis Section (vice-chmn. '49-'50, chmn. '50-'51).

EDGAR L. PIRET—Educator, consultant. Prof. ('45-) Univ. Minn. Fellow ('35-'36) Univ. Lyon. Cons. ('37-), chief chem. engrg. ('43-'45) 3M Co. Fulbright prof. ('50-'51) Univ. Nancy & Paris. European lect. ('50-'51, '54); consul. Naval Res. Lab. ('51-). Dir. ('54-) Minn. peat project. A.I.Ch.E.: Editor, 50th anniv. vol. "Chem. engrg. around world;" advis. bd. A.I.Ch.E. Jour. ('57-); Comm.—Awards ('57-); Intl. Relations ('54-); Publication ('52-). Pres. ('49), dir. ('51-'52, '55-'56) T. C. Section. Progr. chmn. Mpls. mtg. ('50). Walker Award ('55).

CARL C. MONRAD—Educator and Consultant. Prof. ('42) and Head of Dept. ('46-) Carnegie Tech. Ass't ('27-'30) U. Mich.; res. engr. ('30-'37) Stand. Oil (Ind.); Assoc. Prof. ('37-'42) Carnegie Tech. WPB, Office of Rubber Div. ('40-'44). A.I.Ch.E. activities: chmn. prog. Pittsburgh mtg. ('56), Comm.—Program ('47-'48, '55-'56); Housing ('54); vice-chmn. ('56) Educ. & Accrediting; chmn. ('54) Educ. Proj.; chmn. ('52-'53) Student Chapters; past-chmn. Pittsburgh Section.

NOMINATED BY PETITION

L. B. HITCHCOCK—(So. Calif. Sect.)—Industrial consultant. Techn. ('20-'21) H. P. Hood & Sons (Boston); comm. officer ('21-'28) U.S. Army; assoc. prof. ('28-'35) Univ. Va.; mgr. sales devel. ('35-'44) Hooker; mgr. chem. dept. ('44-'46), v.p. ('46-'49) Quaker Oats; pres., dir. res. & devel. ('49-'53) Natl. Dairy; pres. & mgr. dir. ('54-'56) Air Poll. Foundation. A.I.Ch.E.: repres. to A.S.M.E. comm. air poll. controls ('55); Pollution control comm. ('55-'56); chmn. West N.Y. section ('42); chmn. Stud. Prob. comm. ('38); secy. Stud. Chapters comm. ('34-'35).

EMERSON J. LYONS—(New York Section)—Industrial executive. Genl. mgr. ('52-) Turbo-Mixer Div. G.A.T.X. Chem. engr. ('32-'36) Skenandoa Rayon; chem. engr. ('36-'45), chief engr. & mgr. ('46-) Turbo-Mixer. Numerous publ. on mixers & mixer technol. A.I.Ch.E.: Comms.—Admissions ('47-'51, '53-'56), Equip. testing agitat. & absorb. (since inception); Past Inst. repres. to E. J. C.; N.Y. Section—Vice-chmn. ('56-) New Activ. comm. chmn. ('55-), lecture course comm., Section chmn. ('46), vice-chmn. & secy. ('43-'45), stud. guidance comm. ('43-'48).

D. O. MYATT—(National Capital Section)—Industrial executive, editor. Mgr. of Devel., Atlantic Research Corp. Chem. engr. ('38-'46) T.V.A.; mng. editor ('46-'53), I.&E.C., A.C.S.; mgr. of devel. ('53-) Atlantic Research. A.I.Ch.E.: comms.—mbr.('48), vice-chmn. ('57) Symbols & Nomencl., Profes. Guidance ('48-'52); Inst. repres. to A.S.A. Sect. Comm. Z-10, Letter Symbol & Abbrev. ('50-'54); mbr. progr. comm. Washington mtg. ('54); Various Tenn. Valley & National Capital section officer posts & comm. chmnshps. ('47-'57), incl. sect. chmn. ('53-'54).

MEMBERS OF THE NOMINATING COMMITTEE WERE:

W. G. Whitman, Chairman
W. B. Franklin
J. J. Healy
N. W. Krase
J. McAfee
H. F. Nolting
E. R. Smoley
R. E. Vivian

FUTURE MEETINGS

(Continued from page 88)

Streets, Ivorydale, Ohio. **Water Pollution**—C. Fred Gurnham, Dept. of Chem. Eng., Michigan State U., East Lansing, Michigan. **Distillation**—CHAIRMAN: W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. **High-Speed and Time-Lapse Photography in Chemical Engineering**—CHAIRMAN: J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. **Kinetics & Rate Processes**—CHAIRMAN: H. E. Hoelscher, Dept. of Chem. Eng., John Hopkins Univ., Baltimore 18, Md. **New Approaches for Commercial Chemical Development**—CHAIRMAN: H. E. Wessel, Monsanto Chemical Co., 1700 South Second Street, St. Louis, Mo. **Reprocessing of Fluid Reactor Fuels**—CHAIRMAN: O. E. Dwyer, Chemical Engineering Division, Brookhaven National Laboratory, Upton, L. I., N. Y.

1959 MEETINGS

- Kansas City, Mo., May 10-13, 1959. TECHNICAL PROGRAM CHAIRMAN: Fred Kurata, Chemical Engineering Dept., Univ. of Kansas, Lawrence, Kansas.
- San Francisco, Calif., December, 1959. TECHNICAL PROGRAM CHAIRMAN: C. R. Wilke, Division of Chemical Engineering, Univ. of California, Berkeley, Calif.

LOCAL SECTION MEETING

GALVESTON, TEXAS

October 18, 1957. One-day meeting of South Texas Section, A.I.Ch.E. GENERAL CHAIRMAN: John F. Conlon, Union Carbide Chemicals Co.; PROGRAM CHAIRMAN: Henry A. Holcomb, Humble Oil & Refining Co.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

- **Centrifugation:** James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kans. The theory and quantitative aspects of centrifugation.
- **Size Reduction:** Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.
- **Filtration & Centrifugation:** Horace Hinds, Jr., Basic Vegetable Prod. Co., Vacaville, Calif.
- **Chemical Engineering Process Dynamics as They Affect Automatic Control:** David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.
- **Ethylene Manufacture:** Hermann C. Schutt, 201 Devonshire St., Boston 10, Mass.
- **Dry Classification of Solids:** D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.
- **Statistics in Chemical Engineering:** John C. Whitwell, Princeton University, Princeton, N. J.
- **Education of Chemical Engineers:** F. M. Tiller, Dean of Eng., University of Houston, Cullen Blvd., Houston 4, Texas.
- **New Chemical Engineering Construction Techniques:** S. A. Guerrieri, The Lummus Co., 385 Madison Ave., N. Y. 17.
- **Mineral Process Engineering and Mineral Economics:** L. A. Roe, International Minerals & Chemical Corp., 20 North Wacker Drive, Chicago 6, Ill.
- **Foams and Froths:** J. L. York, Dept. of Chem. & Met. Eng., Univ. of Mich., Ann Arbor, Michigan.

• **The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry:** Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.

• **Scale-up from Pilot Plant to Plant:** David B. Coghlan, Foote Mineral Co., Box 576, Berwyn, Pa.

• **Start-Up of New Chemical Plants:** M. L. Nadler, Du Pont, Wilmington, Del.

• **Computers in Optimum Design of Process Equipment:** Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

• **Financing for the Chemical Industry:** Bernard Stott, First National City Bank of New York City, New York, N. Y.

• **Chemical Engineers in Chemical Industry Management:** T. P. Forbath, American Cyanamid Co., 488 Madison Ave., New York, N. Y.

• **Training on the Job for Industry:** John Happel, Dept. of Chem. Eng., N. Y. University, University Heights, New York 53, N. Y.

• **Alternate Energy Sources:** Henry F. Nolting, Standard Oil Co., Whiting, Ind.

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary, A.I.Ch.E., 25 West 45th St., New York 36, N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to latter if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

This year's (1957-58) Podbielniak Institute class schedules on Vapor Phase Chromatographic Techniques and Low and High Temperature Distillation are: Sept. 23-28—reviewing low and high temperature distillation; Sept. 30-Oct. 12—reviewing vapor phase chromatographic techniques; Dec. 2-14—reviewing vapor phase chromatographic techniques; March 3-8—reviewing low and high temperature distillation; March 10-22—reviewing vapor phase chromatographic techniques; May 5-17—reviewing vapor phase chromatographic techniques. □

News of the Field — FROM LOCAL SECTIONS

WHERE TO FIND URANIUM—THE POTENTIAL SOURCES

G. G. Marvin, at present assistant chief of AEC's Engineering Development Branch, Division of Reactor Development, and long-time expert in the field of finding and processing uranium, outlined and analyzed the sources of uranium to the June meeting of the National Capital Section.

In 1950-51, according to Marvin, the amount of uranium available to the AEC was inadequate for the proposed expanded program, and an all-out effort was begun to find how to obtain uranium from any source that could offer yields of appreciable size. In the four to five year period of the program, seven sources were considered.

1) Sea water—some 4-5 parts per billion of uranium.
2) Tennessee shales—about 60 p.p.m. uranium.
3) South Africa gold mining tailings—some 150-250 p.p.m. uranium.
4) Florida phosphate rock deposits—150-200 p.p.m. uranium.
5) North and South Dakota lignites—a few p.p.m. up to significant amounts of uranium.
6) Colorado Plateau ores—0.1 to 0.5 per cent uranium.
7) Expanded work on Canadian ores which are rich in uranium.

On sea water extraction a small amount of work has been done, but concentrations are extremely low, cost of extraction is high, and efforts were not pushed far.

While Colorado shales contain some 30 gallons of oil a ton and traces of uranium, Tennessee shales contain about 10 gallons of oil a ton and some 60 p.p.m. of uranium. This is a significant amount of uranium when the extremely large quantity of the shale available is considered. Potential uranium from this source has been estimated at 5 million tons of U_3O_8. An extensive program was carried out on methods to recover this uranium but the high cost of the final product makes it non-competitive with present supplies of uranium concentrates.

On the other hand, the South African gold mining tailings have proven practical, are today being processed with an output of about 5,000 tons of U_3O_8 a year.

A very small amount of U_3O_8 is

recovered from Florida phosphate rock in several Florida plants, and deposits have been estimated to contain between 500,000 and 600,000 tons of U_3O_8, but again the high cost of recovery makes this source non-competitive.

While the lignites of North and South Dakota at first seemed to have very small percentages of uranium, later work proved the deposits to have more significant amounts. But once more, this source is not competitive.

Colorado Plateau ores are the most productive sources of uranium concentrates in the U. S. today. Ore supply is adequate, processing is not too difficult, recoveries are good. This source will supply some 15,000 tons of U_3O_8 a year to AEC.

Finally, Canadian reserves appear to be as high or higher than those of the Colorado Plateau, and Canadian production of concentrates will probably equal the U.S. within a few years, although the Canadian ore has a lower concentration than Colorado ores.

LOCAL SECTIONS ELECT OFFICERS FOR NEW YEAR

In many ways the backbone of the Institute, local sections and their hard-working officers are too often unknown outside their own areas, and sometimes even inside their own areas. These are the men who give their time to move chemical engineering another step forward, and we think you should know them.

Akron Section officers at present are: T. H. Rogers, chairman; T. F. O'Brien, vice-chairman; R. E. Lynn, Jr., treasurer; and E. W. Campbell, secretary.

Atlanta Section officers now are: N. R. Maleady, chairman; George Howland, vice-chairman; Leroy Hutzler, III, sec.-treasurer; and J. N. Carothers, past chairman.

Baton Rouge Section is being run by: Alfred Smith, III, chairman; T. C. Landrum, vice-chairman; B. J. Beadle, treasurer; and M. O. Gernand, secretary.

Boston Section new officers are headed by F. G. Perry, Jr., chairman; Craig Angell, vice-chairman; Ralph Wentworth, secretary; and Ralph Troupe, treasurer.

(*Continued on page* 96)


Rogers


Maleady


Smith

News of the Field

FROM LOCAL SECTIONS

(*Continued from page 95*)

Perry Green Warner

Central Ohio Section: J. W. Salter, chairman; G. F. Sachsel, vice-chairman; C. E. Dryden, sec.-treasurer.

Central Oklahoma Section: M. S. Worley, chairman; Hayden Roberts, vice-chairman; J. B. West, sec.-treasurer.

Central Pennsylvania Section: R. H. Ghelardi, chairman; H. Sims, vice-chairman; G. S. Stout, sec.-treasurer.

Charleston (W.Va.) Section: R. V. Green, chairman; D. G. Hulett, vice-chairman; L. L. Cavender, secretary; W. F. Taffee, treasurer; and S. A. Savage, member-at-large.

Cleveland Section: H. B. Warner, chairman; D. J. Porter, chairman-elect; F. R. Carvell, secretary; and J. T. Cumming, treasurer.

Coastal Georgia Section: J. M. Mallory, chairman; W. J. Janes, vice-chairman; G. C. McCombs, secretary; and Fred Heubner, treasurer.

Platt Koch Underwood

Columbia Valley Section: A. M. Platt, chairman; J. F. Fletcher, vice-chairman; K. A. Clark, sec.-treasurer.

Dallas Section: H. A. Koch, Jr., chairman; Morris Bock, vice-chairman; J. H. Crow, recording secretary; George Leachman, treasurer; and R. E. Styring, Jr., corresponding secretary.

Detroit Section: R. E. Cavanaugh, chairman; W. W. Leisten, vice-chairman; J. E. Ohlson, secretary; C. E. Wales, treasurer; and J. D. Leslie, director-at-large.

East Tennessee Section: P. C. Underwood, chairman; J. L. Williams, vice-chairman; A. J. Peacock, Jr., sec.-treasurer.

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Great Salt Lake Section: F. W. Bless, Jr., chairman; J. D. Moore, vice-chairman; K. I. Brown, secretary; N. W. Ryan, treasurer.

Idaho Section: J. A. Buckham, chairman; E. S. Grimmett, vice-chairman; W. L. Chase, secretary; and H. V. Chamberlain, treasurer.

Kansas City Section: F. C. Fowler, chairman, John Brown, chairman elect; James Daily, secretary; and E. Oliphant, treasurer.

Knoxville-Oak Ridge Section: R. H. Nimmo, chairman; W. S. Lenihan, chairman-elect; R. J. McNamee, secretary; and W. H. Carr, treasurer. (In this section, Mr. Lenihan has been transferred to Ohio.)

Maryland Section: W. H. Weed, chairman; B. L. Harris, vice-chairman; S. C. Streep, secretary; A. W. Taff, treasurer; and T. O. Tongue, past chairman.

Weed Tusson Crane

New Orleans Section: J. R. Tusson, chairman; O. F. Weidman, vice-chairman; R. H. Stewart, secretary; J. T. Hogan, treasurer.

Northeastern New York Section: Joseph Consiglio, chairman; Hart Lichtenwalner, vice-chairman; Nicholas Ciannamea, treasurer; and William Mullen, secretary.

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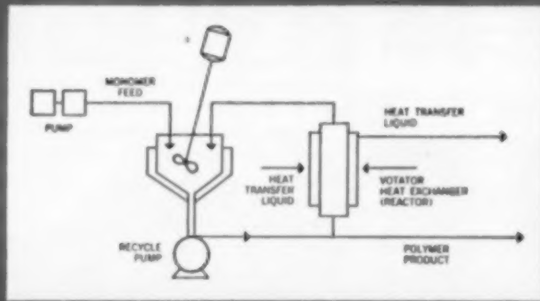
Pittsburgh Section: C. A. Bishop, chairman; J. R. West, vice-chairman; V. N. Hurd, secretary; R. E. Ryan, treasurer.

Rhode Island Section: A. R. Thompson, chairman; J. L. Campanella, vice-chairman; C. A. Stoeckel, sec.-treasurer.

Rochester Section: Richard Kray-

(*Continued on page 98*)



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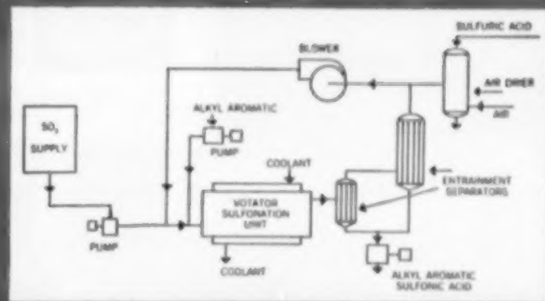

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News of the Field

FROM LOCAL SECTIONS

(*Continued from page 96*)

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Schroeter

bill, chairman; B. M. Johnson, vice-chairman; W. C. Morin, treasurer; J. A. Mason, secretary.

Sabine Area Section: W. S. Bonnell, chairman; W. F. Sheldon, chairman-elect; L. W. Dussell, sec.-treasurer.

Savannah River Section: E. C. Bertsche, chairman; D. C. Webster, vice-chairman; R. O. Pekkala, secretary; J. C. Blair, treasurer.

Southern California Section: B. B. Kuist, chairman; P. M. Huemmer, vice-chairman; P. F. Lueth, secretary; and D. K. Peterson, treasurer.

South Texas Section: D. G. Schroeter, chairman; C. L. Fitzgerald, Jr., chairman-elect; E. E. Ludwig, secretary; D. A. Duke, treasurer; and W. L. Bolles, past chairman.

St. Louis Section: E. D. North, chairman; R. O. Nellums, vice-chairman; R. C. Johnson, secretary; H. Hilliker, treasurer.

North

Megar

Haas

Tennessee Valley Section: G. H. Megar, chairman; E. C. Ogden, R. F. McQueen, S. G. Kyle, vice-chairman; Cecil Rose, secretary; and P. W. Gann, treasurer.

Terre Haute Section: T. W. Cundiff, chairman; John Jackson, vice-chairman; Warren Clausen, secretary; and R. E. Finch, treasurer.

Texas Panhandle Section: H. W. Haas, chairman; R. M. Green, vice-chairman; C. M. Oktay, secretary; and V. W. Jones, treasurer.

Tidewater Virginia Section: B. L. Hinkle, chairman; R. N. Tennyson, vice-chairman; W. H. Wright, secretary; and P. S. Calvo, treasurer.

Toledo Section: Andrew Kassay, chairman; Clyde Balch, vice-chairman; Robert Hunter, secretary; and Jay Trexler, treasurer.

Tulsa Section: H. L. Lawler, chairman; E. W. Kilgren, vice-chairman; and A. W. Hunt, sec.-treasurer.

Washington-Oregon Section: J. B. Heitman, chairman; L. N. Johanson, vice-chairman; and F. J. Shelton, sec.-treasurer.

Kassay

Lawler

Altimier

Western New York Section: D. F. Altimier, chairman; R. L. Logan, vice-chairman; Aaron Rose, secretary; F. R. Pence, treasurer.

Pending Sections, Too

CEP wants to welcome the officers of two prospective sections:

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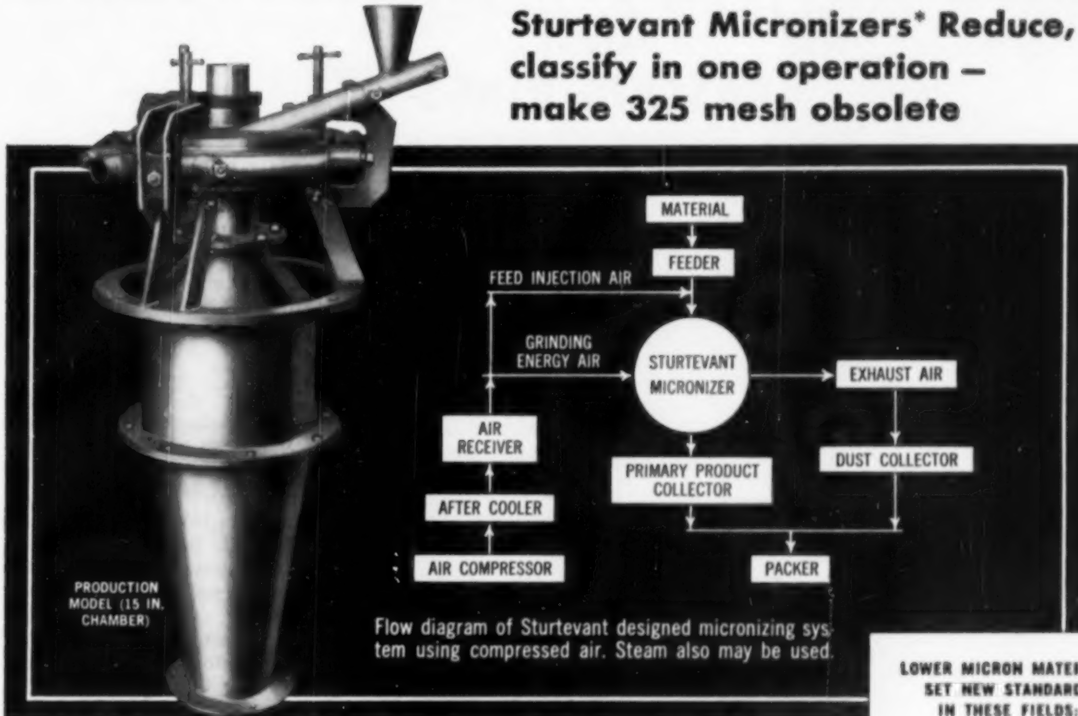

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Laboratory test-micronizing of your own material, or production micronizing on contract basis, are part of Sturtevant service. See for yourself the improvement ultra-fine grinding can contribute to your product. Or, if you have limited requirements for ultra-fine grinding, Sturtevant's contract micronizing service may be the economical answer. Write for full details.

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A 30 in. Sturtevant Micronizer is reducing titanium dioxide to particle size under 1 micron at a feed rate of 2250 lbs. per hr. For another firm, a 24 in. model grinds 50% DDT to 3.5 average microns at a solid feed rate of 1200 to 1400 lbs. per hr. A pharmaceutical house is using an 8 in. model to produce procaine-penicillin fines in the 5 to 20 micron range. Iron oxide pigment is being reduced by a 30 in. Micronizer to 2 to 3 average microns at rates of 1000 lbs. per hr. Sturtevant Engineers will help you plan a Fluid-Jet system for your ultra-fine grinding and classifying requirements. *Write today.*

* REGISTERED TRADEMARK OF STURTEVANT MILL CO.

STURTEVANT

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people

Alfred T. Zodda appointed vice-president, operations, for Olin Mathieson International Corp. Zodda, formerly general manager of Olin Mathieson's Squibb International Division, will be responsible for all overseas operations of the corporation, including production and marketing.

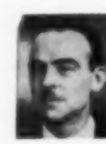
Zodda

Dorr-Oliver announces that **Anthony Anable** has rejoined their staff as manager of the Technical Data Division.

New member of the development staff of the Packaging Division of Procter & Gamble is **M. E. Lavrich.**

Recently-chosen honorary members of the American Institute of Chemists are: **Arnold O. Beckman,** president of Beckman Instruments, Inc.; **Harold A. Levey,** president of American Products Mfg. Co.; **Bernard E. Schaar,** president of Schaar & Co.; and **W. E. Hanford,** vice-president of M. W. Kellogg Co.

Scientific Design Co. names **Thomas P. Brown** and **Walter N. Alexander** as senior vice-presidents. New vice-presidents will be **Henry F. Peters** (engineering), **David Brown** (research and development), and **Philip E. Newman** (European affairs). Other advancements at Scientific Design include: **Gregory F. Vinci** to director of the Operating Department; **Russell G. Hill** to technical assistant to the vice-president, engineering; and **John W. Colton** to director of Process Development.



Brown

Alexander

Promotions at Humble Oil & Refining Co. include: **H. G. Boynton, E. W. Lewis,** and **J. R. Miller** to senior research chemical engineers in the Research and Development Division at the company's Baytown, Texas, refinery; **J. R. Lander** and **W. G. Denning** as senior chemical engineers in the Technical Service Division. New staff member of the Technical Service Division is **W. S. Reaves.**

(*Continued on page* 108)

To a ball-point pen anything over 5 microns in size is a

"clinker" in the ink

Removing such "clinkers" is one of many jobs for which the Sharples Super Centrifuge is ideally suited—continuous clarification of liquids, separation of two immiscible liquids, removal of solids according to particle size . . . by means of the highest centrifugal force commercially available—**13,200 x G.**

The Sharples Super Centrifuge performs many process functions at lower cost and with greater efficiency than by other means. A test run in the Sharples Laboratory may be arranged to demonstrate this superior performance.

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Associated Companies and Representatives Throughout the World

CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before September 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Allport, H. B., *Cleveland, Ohio*
Barner, C. R., *Lake Jackson, Tex.*
Bienenfeld, Norman, *Cranston, R. I.*
Brown, G. B., *Bound Brook, N. J.*
Clements, Porter, *Chicago, Ill.*
Csanady, E. R., *Washington, D. C.*
Cummings, Ralph, *Los Angeles, Calif.*
Durflinger, Glen E., *Freeport, Tex.*
Fisher, Webster E., *Rochester, N. Y.*
Fitzgerald, Francis A., Jr., *Westfield, N. J.*
Hayworth, Henry C., *New York, N. Y.*
Hearn, John V., Jr., *Dayton, Ohio*
Henderson, Harry L., *Charleston, W. Va.*
Hodges, W. A., *Plant City, Fla.*
Hook, Donald E., *Midland, Mich.*
Imsande, Robert R., *Pittsfield, Mass.*
Ivey, Edwin H., Jr., *Lake Jackson, Tex.*
Johnson, Robert A., *Casper, Wyo.*
Kelly, William A., *Teaneck, N. J.*
Kirchheimer, Ernest W., *Houston, Tex.*
Kramer, Franklin, *Woburn, Mass.*
Kunkel, Lorenz V., *Tulsa, Okla.*
Landau, Ralph, *New York, N. Y.*
Lankenau, Henry G., *Clifton, N. J.*
Lebherz, Robert W., Jr., *Frederick, Md.*
Lutz, John H., *Wyckoff, N. J.*
Mair, John D., *Windsor, Ontario, Can.*
Mangelsdorf, T. A., *New York, N. Y.*
Marple, Stanley, Jr., *Houston, Tex.*
McClain, James H., *Albany, Ore.*
Miller, John S., Jr., *Memphis, Tenn.*
Miller, Robert N., *Atlanta, Ga.*
Norman, Lloyd W., *Colorado Springs, Colo.*
Parkhurst, Robert F., *Indian Head, Md.*
Rescorla, Arthur R., *Westfield, N. J.*
Richardson, A. C., *Columbus, Ohio*
Rush, J. B., *Mission, Kansas*
Salmon, Royes, *Philadelphia, Pa.*
Strickler, G. C., Jr., *Barberton, Ohio*
Summerfield, John M., *Skokie, Ill.*
Tallman, Ralph C., *El Dorado, Ark.*
Turner, Max A., *Lynchburg, Va.*
Vessey, Harold M., *So. Charleston, W. Va.*
White, L. P., *Houston, Texas*
Wiesner, George L., *Bound Brook, N. J.*

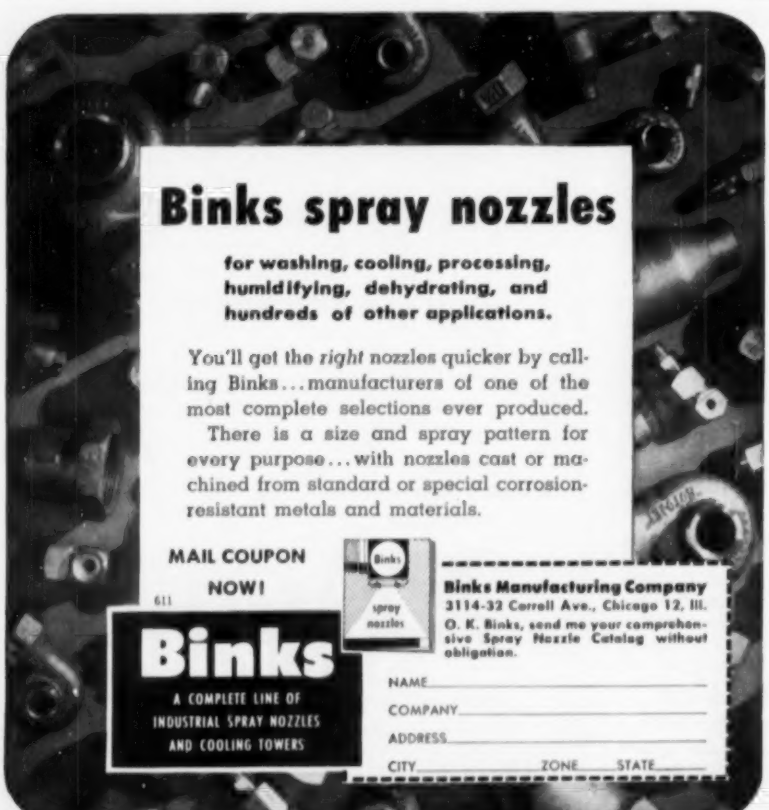
Associate Member

Addison, G. Edgar, *Des Plaines, Ill.*
Aldous, Edward A., *Kerville, Tex.*
Altschuler, Sid, *No. Bergen, N. J.*
Auerbach, Eric E., *Pleasantville, N. Y.*
Augsdorfer, Jules P., *Newark, N. J.*
Badame, Paul J., *Camden, N. J.*
Bagley, [illegible]dinand A., Jr., *Montclair, [illegible] J.*
Balekjian, Garen, *Alhambra, Calif.*
Banks, Carl W., Jr., *Medina, N. Y.*
Barb, Darold K., *Augusta, Kansas*
Barber, Robert W., *Lynn, Mass.*
Barrett, Francis M., *Denver, Colo.*
Barrett, Stuart W., *Rome, N. Y.*
Bassler, Edwin, *Queens Village, N. Y.*
Becker, Robert H., *Lakewood, Ohio*
Begany, Dennis J., *Peekskill, N. Y.*
Benton, Roger M., *Alma, Okla.*
Berkow, Herbert N., *Brooklyn, N. Y.*
Berkowitz, Edward, *Brooklyn, N. Y.*
Berkowitz, Leonard, *Brooklyn, N. Y.*
Bernas, Arnold, *Brooklyn, N. Y.*
Bertus, R. J., *New Orleans, La.*
Bierker, George, *Flushing, N. Y.*
Blong, Timothy P., *Conshohocken, Pa.*
Boldt, Donald B., *Jesup, Iowa*
Boldt, Roy C., *White Bear, Minn.*
Brahler, Paul S., *Washington, D. C.*
Brandenburg, Joe T., Jr., *Bamberg, S. C.*
Brettschneider, Arnold N., *Brooklyn, N. Y.*
Brewton, Edward A., *Norfolk, Va.*
Brown, E. Harry, *Gainesville, Ga.*
Brown, Ralph, *Brookline, Mass.*
Brown, Virgil B., *Baytown, Texas*
Bugg, S. R., Jr., *Webster Groves, Mo.*
Burrus, Mitchell, *Charleston, W. Va.*
Bush, William D., *Wauwatosa, Wis.*
Butter, Howard D., *Pasadena, Texas*
Camp, Frederick W., *Arlington, Va.*

CANDIDATES *(Continued)*

Connizzaro, Antonio Santo, *Dearborn, Mich.*
Carls, Edwin L., *Chicago, Ill.*
Caro, Richard H., *Baton Rouge, La.*
Cart, Eldred N., Jr., *Louisville, Ky.*
Castleman, A. W., Jr., *Buffalo, N. Y.*
Cecchetti, Ralph, *College Park, Md.*
Chaplin, Noel, *Highlands, Texas*
Choudhury, A. P. Ray, *Calcutta, India*
Choy, George D., *Waterford, N. Y.*
Claybough, Bill E., *Ponra City, Okla.*
Click, Clifford N., *Reynyoldsburg, Ohio*
Cohn, Burton M., *Chicago, Ill.*
Collins, Braxton W., *Bennettsville, S. C.*
Connon, Warren N., *Brooklyn, N. Y.*
Cooke, Robert R., *Asheboro, N. C.*
Corey, Donald L., *Grosse Pointe, Mich.*
Cotter, James D., *Idaho Falls, Idaho*
Coury, Glenn E., *Houston, Tex.*
Crawley, James, *Van Nuys, Calif.*
Cross, Robert A., *Bauxite, Ark.*
Cutright, Eugene A., *Lake Charles, La.*
Dahlgren, Edwin H., Jr., *Springfield, Mass.*
D'Amato, Sylvio F., *Bronx, N. Y.*
Davis, Richard K., *Malvern, Pa.*
De Salvo, Francis, *Wheaton, Ill.*
Dimoplon, William, Jr., *New York, N. Y.*
Dommel, Charles W., *Houston, Tex.*
Donaldson, Glenn B., Jr., *Berkeley, Calif.*
Donovitch, Joseph K., *Midland, Mich.*
Douglad, Colin N., *Army Chemical Center, Md.*
Durnan, Dennis D., *Blaine, Wash.*
Edelmann, Julius J., *Brooklyn, N. Y.*
Edwards, Charles L., *Abilene, Tex.*
Egner, Rockie R., *San Francisco, Calif.*
Emanuele, Herman J., *Frederick, Md.*
Essig, John R., *Dover, N. J.*
Farina, Robert Donald, *Schenectady, N. Y.*
Farmer, Earl P., Jr., *Shreveport, La.*
Faulkner, Robert, *Northampton, Mass.*
Ferguson, Thomas G., *Cohoes, N. Y.*
Fidelman, Stanley, *Brooklyn, N. Y.*
Firstenberg, Henry, *Brooklyn, N. Y.*
Fishman, Norman, *San Jose, Calif.*
Floyd, John C., *Columbia, S. C.*
Ford, Johnny G., *Beaumont, Tex.*

(Continued on page 104)



CANDIDATES

(*Continued from page* 103)

Foss, Robert J., *East Patterson, N. J.*
Friedlander, Jacob, *New York, N. Y.*
Fulmer, Richard D., *Alhambra, Calif.*
Gallagher, James, *Jamaica, N. Y.*
Gastwirt, Lawrence, *Brooklyn, N. Y.*
Gerber, Norman H., *Corpus Christi, Texas*
Gex, V. E., *Cincinnati, Ohio*
Gibson, Ernest L., *Springfield, Pa.*
Gilbert, Paul, *Emmet, Ark.*
Gilbert, William C., *Denver, Colo.*
Givalt, Luis, *Habana, Cuba*
Gilchrist, Edward M., *Albuquerque, N. M.*
Glotfelty, Charles Adrain, *Terra Alta, W. Va.*
Gluck, Donald, *Bronx, N. Y.*
Glueck, Alan Robert, *Shaker Heights, Ohio*
Godwin, John B., Jr., *Ada, Okla.*
Goldfarb, Stanley, *Bronx, N. Y.*
Gorman, Robert V., *Savannah, Ga.*
Graulich, Barry, *Camillus, N. Y.*
Grant, Barrie, *Brooklyn, N. Y.*
Greene, Morton, *Brooklyn, N. Y.*
Griffith, Don E., *Floyd, Iowa*
Groening, Harvey, *Lawrence, Kansas*
Guttman, Sidney, *Brooklyn, N. Y.*
Hague, S. M. M., *Dacca, East Pakistan*
Hajek, James D., *Lake Jackson, Tex.*
Hanratty, James J., *Houston, Tex.*
Harlan, Howard E., *Mars, Pa.*
Harlow, Gordon, *Spencer, W. Va.*
Harper, Dean Owen, *Huntsville, Ala.*
Harris, Bill J., *LaMarque, Texas*
Haskins, David E., *Great Neck, N. Y.*
Hebert, Alfred Jean, Jr., *Agawam, Mass.*
Hecht, Malcolm, Jr., *Belmont, Mass.*
Heil, John F., *San Francisco, Calif.*
Heilen, Robert J., *Ridgewood, N. Y.*
Heise, Fred H., Jr., *Tuckahoe, N. Y.*
Hill, Frank Smith, Jr., *Vicksburg, Miss.*
Hirsch, Bruno P., *No. Bergen, N. J.*
Hoffman, E. J., *Boulder, Colo.*
Hoffman, Robert F., *Riverside, N. J.*
Hoglen, John J., *New Albany, Ind.*
Holman, Kermit L., *Morris, Minn.*
Holoman, William Chreston, *Raleigh, N. C.*
Hooper, Charles B., *Hammond, Ind.*
Hopper, James M., *Bauxite, Ark.*
Howard, William Michael, Jr., *Utica, N. Y.*
Hsieh, George J., *New York, N. Y.*
Huester, Peter K., *Scranton, Pa.*
Jagger, Bruce, *Lingle, Wyo.*
James, Ben F., Jr., *Charleston, W. Va.*
Jaskot, Richard J., *Garfield, N. J.*
Jones, Edward C., *Winchester, Mass.*
Jones, Harold F., *Syracuse, N. Y.*
Jones, Hugh E., *Port Arthur, Texas*
Jones, Robert Dale, *South Gate, Calif.*
Jones, Robert Dale, *Jackson, Michigan*
Jacobs, Thomas A., *Texas City, Tex.*
Jurman, Robert L., *Midland, Mich.*
Karnath, Albert W., *Kenmore, N. Y.*
Karp, Morris E., *Corpus Christi, Texas*
Kelly, William T., *Dorchester, Mass.*
Kilpatrick, James C., Jr., *Fredericksburg, Va.*
Kirby, Timothy, *New York, N. Y.*
Kirchner, Carl E., Jr., *Avon, Ohio*
Klee, Harvey J., *Brooklyn, N. Y.*
Koh, Choong, Kyu, *Flushing, N. Y.*
Konstam, Aaron, *Bronx, N.Y.*
Kooyman, William John, *Cincinnati, Ohio*
Krause, Richard E., *Great Falls, Montana*
Krauss, William, *New York, N. Y.*
Krueger, Henry F., *Keokuk, Iowa*
Land, Jane Asbil, *York, S. C.*
Lavin, Arthur, *Schenectady, N. Y.*
Lawrence, Whitney E., *El Cerrito, Calif.*

Lee, Kung Hsing, Wilmington, Del.
Lenoir, Donald R., Baytown Tex.
Leone, Nicholas L., Huntington Station, N. Y.
Lescelius, Raymond O., Keweenaw Bay, Mich.
Lichtenwalner, Hart K., Rexford, N. Y.
Littlefield, John L., Wilmington, Del.
Ljunglin, James J., Albertson, N. Y.
Loflin, Harry L., Jr., Pasadena, Texas
Lorenzene, B. Edward, East Northport, N. Y.
Lowrey, Erlend R., Morristown, N.J.
Lucey, John W., Schenectady, N. Y.
Mandell, Edward, Brooklyn, N. Y.
Mariani, Francis R., East Boston, Mass.
Markbreiter, Stephen J., New York, N. Y.
Markley, Gordon W., Whittier, Calif.
Marsh, William Dale, Netcong, N. J.
Massot, Kenneth L., St. Louis, Mo.
Mazzanti, John, Bronx, N. Y.
McBride, Thomas G., Jr., Maywood, Ill.
McGurhill, Gerald, Ottawa, Ontario, Canada
McKee, Joe M., Birmingham, Ala.
McMahon, Terrence K., Plainfield, N. J.
McWhorter, William C., Nashville, Tenn.
Mehring, Thomas Gregory, Antioch, Calif.
Melton, M. Shannon, Tulsa, Okla.
Menees, Elbert L., Jr., Anderson, S. C.
Mercando, Lawrence E., Flushing, N. Y.
Miller, James B., Fort Smith, Ark.
Miller, Jed J., Odessa, Texas
Miller, Roy E., St. Louis, Mo.
Mixon, William R., Little Rock, Ark.
Moore, Calvin E., Jr., College Station, Tex.
Moore, George R., Emeryville, Calif.
Moore, Roy G., Manistique, Mich.
Moorse, Ronald V., Niagara Falls, N. Y.
Moroney, Robert G., Houston, Tex.
Morris, Herbert D., Brooklyn, N. Y.
Moser, R. M., Tulsa, Okla.
Moyer, Howard R., Marcus Hook, Pa.
Mullen, James J., Baton Rouge, La.
Murphree, Leland Charles, Jr., Gainesville, Ga.
Murphy, Michael J., Springfield, Mass.
Murray, Lawrence P., Jr., Waynesboro, Va.
Mykytiuk, Donald, So. Hardley Falls, Mass.
Narita, Susumu, New York, N. Y.
Nelson, Howard, Brooklyn, N. Y.
Ostroff, Leonard A., Oaklyn, N. J.
Parsons, Larry B., E. Bangor, Pa.
Pastrana, Orlando, Bogota, Columbia
Peller, Paul, Buffalo, N. Y.
Pellicer, George L., New York, N. Y.
Peltzer, Ronald P., Upperco., Md.
Phair, Lynn, Saginaw, Mich.
Pickens, Gene, Brooklyn, N. Y.
Pitt, W. Wilson, Jr., Red Oak, N. C.
Plotkin, Morris B., Bound Brook, N. J.
Prickett, Percy Lee, Fairmount, W. Va.
Prober, Richard, Chicago, Ill.
Purves, Edward R., Columbus, Ohio
Rangel, E., Midland, Mich.
Richter, R. E., Ontario, Canada
Ritchie, William E., Haverhill, Mass.
Rogers, Philip A., Glen Cove, N. Y.
Rolfe, Gerald T., New York, N. Y.
Ross, Donald E., New York, N. Y.
Rossen, Jack L., Flushing, N. Y.
Rowland, O. B., Jr., Bastrop, La.
Rudolph, Charles F., Jr., Cheltenham, Pa.
Rutkowski, Lawrence, Bronx, N. Y.
Sabian, Gerald, Troy, N. Y.
Sacharuk, Serge, New Haven, Conn.
Salzman, Michael, Brooklyn, N. Y.
Sanders, Eugene F., St. Louis, Mo.
Schefflan, Ralph, New York, N. Y.
Schladensky, George F., Cooleemee, N. C.
Schlich, William R., Louisville, Ky.
Schnur, David Martin, New York, N. Y.
Schoneman, Donald P., Albany, N. Y.

(Continued on page 111)

CEP CAMERA

NEW ENGINEERING CENTER

Site of the new United Engineering Center will be on famed United Nations Plaza in New York, directly opposite the beautiful park of the "World Headquarters." Location is both practical and symbolic for a Center which will house the five "united" societies (AIME, AIEE, ASME, ASCE, and AIChE), will enhance the national and international importance of engineering today. Exact spot is the entire block front on United Nations Plaza (First Avenue) between 47 and 48 Streets. The location is close to Grand Central Station, is near FDR Drive for convenient access by automobile, combines the convenience of a midtown New York location with the "peaceful" atmosphere of the UN area. Totalling 37,500 sq.ft., the site was bought by United Engineering Trustees at a cost of about $2,700,000. Preliminary work on actual building plans has already begun.

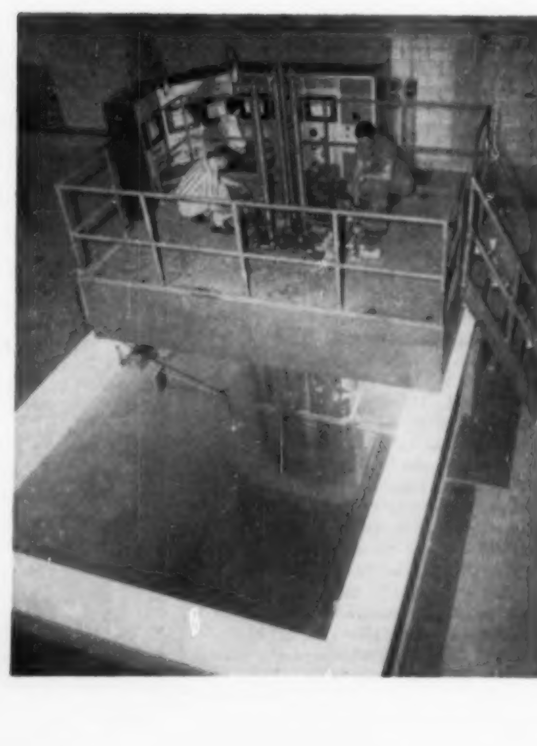
Fairchild Aerial Surveys, Inc.

MOBILE EXHIBIT

Designed to give on-the-spot operating demonstrations of Fischer & Porter's products to customers, technical schools, and engineering societies, this mobile exhibit is completely equipped with the company's instruments and equipment for the process industries. Mobile unit has already done its work at a recent TAPPI meeting at Lake Placid, is now touring California and heading east across the South, stopping at process plants on the way.

NUCLEAR PROGRESS

A test reactor for a test reactor! The Engineering Test Reactor Critical Facility at Idaho Falls (right) is a full-scale mockup of the core and reflector of the Engineering Test Reactor which will go critical this fall. Purpose of ETRC is to obtain data needed for the safe operation of ETR without spending valuable portions of ETR's operating time, allowing ETR to be free to perform its irradiation testing work. Designer, builder, and operator of both ETRC and ETR is Phillips Petroleum.



Heat produced by the nuclear reactor in the building at the right generates electricity in the experimental power station installed by Southern Edison Co. (left). Reactor is part of Atomics International's Sodium Reactor Experiment conducted for AEC in the Santa Susana Mountains near Los Angeles.

PLANT TOUR

Chemical engineering and chemistry profs tour Chemstrand's Decatur, Ala., plant to get first hand view of chemical textile fiber operations. On this tour, first in a planned series, the educators are (l. to r.): R. L. McKee, U. of N. Carolina; W. K. Neill, U. of Wisconsin; A. H. Bruner, Chemstrand; K. W. Coons, U. of Alabama; R. H. Henze, U. of Texas; and G. B. Butler, U. of Florida.

PFAUDLER PRE-TEST LAB AIDS EQUIPMENT BUYER ►

What was once an informal testing program at Pfaudler's Rochester plant is now a full-scale, formalized customer research project. At first a small laboratory, it has been enlarged and now contains enough diversified equipment to pilot test virtually any corrosive process material. Result: Pfaudler customers are certain that glassed steel equipment will work in their processes before they ever purchase the equipment from Pfaudler.

One of the latest pieces of equipment added to the lab is the newly designed wiped film evaporator shown in picture 1. A new concept in the design of evaporators, in the wiped film evaporator the walls of the still are actually contacted by wipers made of carbon or materials such as Teflon. By being in constant contact with the walls, the wipers reduce film thickness to a uniform controlled minimum. The use of wiping action improves heat transfer, shortens contact time for distillate, makes a low cost process.

Another new piece of equipment is a glassed steel conical dryer-blender (picture 2) that can be used for every acid except hydrofluoric up to 212° F., and for alkalis up to pH 12 to 212° F. In photo 4 are the steam jacketed tank and 100-gallon reactor, and in picture 3 a worker prepares two Titan centrifuges for tests.

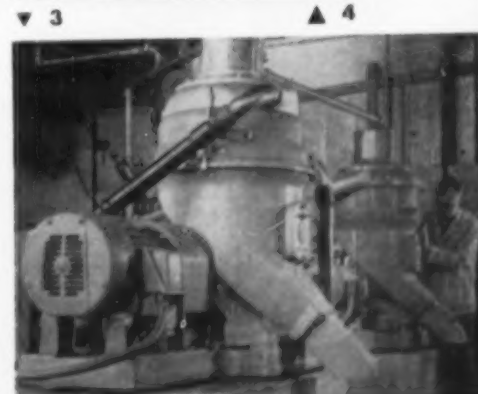
DRYER

One of two all-welded aluminum steam tube dryers which will be installed in W. R. Grace's low-pressure polyethylene plant at Baton Rouge, La., by the Fluor Corp. Built by Standard Steel Corp., the welded construction will result in considerable saving in the cost of drying equipment.

▲ 1

▲ 2

▼ 3 ▲ 4



people

William B. Bowman, assistant general manager, Organic Chemicals Division, American Cyanamid Co., is the newly-elected honorary chairman of the American Section, Society of Chemical Industry, for 1957-1958.


Bowman

Promotions and staff additions in the Chemical Engineering Department, Johns Hopkins University, include promotion of **H. E. Hoelscher** to professor and appointment of **S. K. Friedlander** and **Willard Bastian** as assistant professors.

Kenneth M. Watson, former vice-president of the Pure Oil Co., was the featured speaker at a recent meeting of the Society of Sigma Xi at Illinois Institute of Technology. Watson was 1948 winner of the William H. Walker Award.

At the South Charleston, W. Va., plant of Union Carbide Chemicals Co., **H. W. Schulz** has been appointed associate director, Development Dept.

G. Lloyd Martin joins National Research Corporation as assistant director of the Chemistry Department, where he will be responsible for inorganic chemistry and process development. Martin comes to National Research from Mallinckrodt Chemical Works.

Minnesota Mining & Manufacturing promotes **Alva L. Frye** to manager of their Central Research Laboratory pilot plant. Frye is chairman of the Twin City Section, A.I.Ch.E.

Personnel changes at Houdry's Philadelphia Process Sales and Engineering Division include appointment of **D. E. Womeldorph** as commercial development engineer and of **R. G. Craig** as senior process design engineer.


Toole

New head of the Production Department at the Niagara Falls, N. Y., plant of B. F. Goodrich Chemical Co. is **Robert L. Toole.**

J. Howard Zeh named plant manager of the Perry, Ohio, carbon bisulfide plant of Stauffer Chemical Co.

T. J. Coleman, formerly associate technical director, becomes vice-president of Union Carbide Development Co.

Rayonier, Inc., announces retirement of **Russell M. Pickens,** vice-president of the company since 1949. Pickens, who joined Rayonier in 1930 as technical director, will continue to serve the company in the capacity of consultant.


Pickens

Robert H. Kean has received the Distinguished Service Award of the American Chemical Society for 1957. Kean has also been an officer of the Virginia Section of the A.I.Ch.E. and was instrumental in its founding.

Wyandotte Chemicals Corp. appoints **J. R. Heard, Jr.** and **N. S. Nichols** as supervisors in charge of process development in their Chemical Engineering Research Department.

Clifford L. Sayre named director of central chemical engineering for the Chemical Divisions of Food Machinery and Chemical Corp. Sayre will be responsible for major plant design and construction, and industrial engineering.


Sayre

Henry J. Masson, assistant dean in charge of the Graduate Division at N.Y.U.'s College of Engineering, retires after 40 years of continuous service to the University. Masson has done intensive research in the field of petroleum technology and has served as industrial consultant to the industry.

Joseph Cerny, 3rd, senior in chemical engineering at the University of Mississippi, is awarded a National Science Foundation Fellowship and a Fulbright Scholarship to study nuclear engineering at the University of Manchester, England.


Cerny

O. A. Hougen, Professor of Chemical Engineering at the University of Wisconsin, sails for Japan in August. Hougen, at the request of the Fulbright Commission of Japan, will be associated with the chemical engineering department of Kyoto University for one semester.

(Continued on page 110)

people

Gaines

New associate technical director of the Linde Co. is **J. M. Gaines.** Gaines was formerly director of research for the company.

Richard G. Rowe announces opening of his Redding Ridge, Conn., office for the practice of chemical engineering.

D. W. Oakley, previously technical advisor to the president, has been made production manager at Metal & Thermit Corp., New York.

Hooker Electrochemical Co. announces appointment of **Morton S. Kircher** as research manager in charge of inorganic and electrochemical research and the Virgo laboratory, negotiations for licensing the Hooker cell, and research at the Hooker-operated A.E.C. boron isotope plant in Model City.

Nevin K. Hiester, manager of the Chemical Engineering Section at Stanford Research Institute, was a speaker at the recent 1957 meeting of the A.S.M.E. in San Francisco. His subject: "A New Solar Furnace Installation."

Sconce

James S. Sconce named technical assistant to management at Hooker Electrochemical Co., Niagara Falls, N. Y. Sconce was formerly manager of chemical research at Hooker.

Olin Mathieson Chemical Corp., Industrial Chemicals Division, names **Kennett Lewis** as project engineer and **John R. Koehn** as assistant project engineer.

Grant E. Russell will become manager of the Systems Section of the Engineering Department of Monsanto Chemical's Research and Engineering Division. Russell has been on academic leave of absence for the past year to study automatic process control at the University of Minnesota.

Newly-elected vice-presidents of Atlantic Research Corp. are **Lester L. Weil** and **Keith E. Rumbel.** Both men have long been active in the development of solid fuels for rocket and missile applications.

New members of the engineering staff of Great Northern Oil Co. are **Juergen J. Bloess** and **Mark A. Halepeska.**

A. S. Gilliam, plant manager of Great Northern Oil's Pine Bend refinery, has been elected a vice-president of the firm. Prior to joining Great Northern in 1956, Gilliam was an executive of Olin-Mathieson Chemical Corp.

The fourth annual Max Hecht Award of the American Society for Testing Materials was presented this year to **Robert C. Adams,** superintendent of the Chemical Engineering Laboratory, U. S. Naval Experiment Station, Annapolis, Md.

De Largey

Robert J. DeLargey becomes assistant division manager, operations, of the Westvaco Chlor-Alkali Division of Food Machinery & Chemical Corp. DeLargey was formerly director of engineering for FMC's Chemical Divisions.

James E. Hippler joins staff of McGean Chemical Co., Cleveland, Ohio, as a process improvement engineer.

New manager of the Westinghouse metals plant at Blairsville, Pa., is **R. D. Rowley.** Before joining Westinghouse in 1948, Rowley was plant superintendent for the Celanese Corp.

Henry D. Berkowitz named to the exploratory development staff of the Research and Development Department of Procter & Gamble Co.

Bruce S. Phalen named supervisor of the Coating and Solvent Recovery Sections, Coating Department, in the Film Division of the Marcus Hook plant of American Viscose Corp.

Schuette

Dow Chemical Co. announces election of **William H. Schuette** to the company's board of directors. Since 1955, Schuette has been general manager of Dow's Midland Division.

New research project analyst for the A. E. Staley Manufacturing Co. is **Richard M. Lawrence.** Lawrence comes to the Staley Co. from Wyandotte Chemicals Co., Dearborn, Mich.

(Continued on page 117)

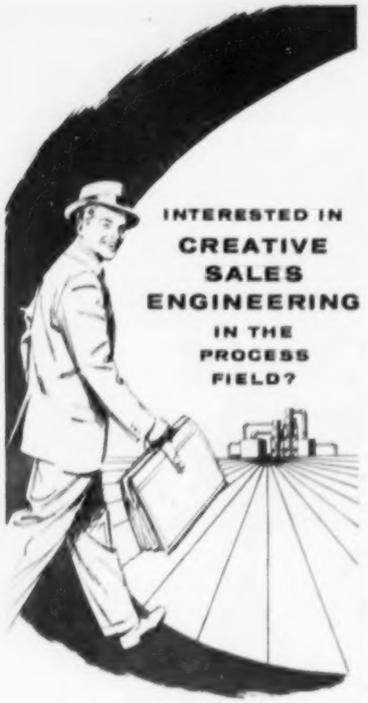
CANDIDATES

(Continued from page 105)

Schrey, Frank, Whitestone, N. Y.
Schulz, Floyd R., Pasadena, Calif.
Schwartz, Allen, Jackson Hgts., N. Y.
Seever, Larry E., Clinton, Iowa
Sharlit, Ian B., New York, N. Y.
Shaw, Henry, Brooklyn, N. Y.
Sheppard, Louis C., Pasadena, Texas
Shockley, Charles C., Wilmington, Del.
Sings, Jack, Northbrook, Ill.
Skabo, R. R., Tioga, N. D.
Skarpelos, John M., Richland, Wash.
Smith, Jay S., Janesville, Wis.
Smith, William E., Cohoes, N. Y.
Somes, Daniel E., Sault Ste. Marie, Mich.
Sotak, Robert E., Ormrod, Pa.
Spacafora, Paul F., Bronx, N. Y.
Stabile, Ronald, New York, N. Y.
Stamm, Charles F., Johnson City, Tenn.
Steele, B. Lee, Montrose, Colo.
Stibolt, Victor D., Longview, Wash.
Stone, Fred W., Charleston, W. Va.
Stracey, Stanley T., Brooklyn, N. Y.
Sullivan, John J., Chicago, Ill.
Taikeff, Elliott A., Brooklyn, N. Y.
Teplitz, Jerome M., Philadelphia, Pa.
Tomlinson, Eugene M., Dearborn, Mich.
Thompson, La Roy B., Rochester, N. Y.
Thorpe, Curtis A., Grand Forks, N. C.
Tipton, James A., Brownsville, Tenn.
Tooke, Thomas H., Springfield, Mass.
Tusch, Robert, Ada, Mich.
Tyrrell, Chester C., East Lake, Michigan
Utz, Gabriel Crisler, Baytown, Texas
Van Breedam, F. J., Yorktown, Va.
Van Bueren, P. C. L., So. Norwalk, Conn.
Vanden Boom, Jerry L., Lovell, Wyo.
Wachtil, Stephen, Brooklyn, N. Y.
Wahl, Dewey, McClusky, N. D.
Waldman, Joseph L., Brooklyn, N. Y.
Walker, R. B., Seattle, Washington
Waltrick, Paul F., Glenside, Pa.
Watson, Gene, Roseville, Mich.
Weber, Arthur G., Wilmington, Del.
Weilacher, Robert G., New York, N. Y.
Weiner, Robert Michael, La Porte, Ind.
Weintraub, Myron S., Atlantic City, N. C.
Welsh, Charles B., Philadelphia, Pa.
Wheeler, Donald E., Augusta, Kansas
Wieder, Lawrence Z., Portland, Oregon
Wilkes, Joseph G., Peckville, Pa.
Willburn, Luke J., Jr., Union, S. C.
Williams, Eugene, Monroeville, Pa.
Williams, John F., Dallas, Texas
Williamson, E. Floyd, So. Charleston, W. Va.
Wilson, John C., Kilgore, Texas
Wise, James F., Fremont, Ohio
Wohl, Martin H., Riverdale, N. Y.
Wolf, Kenneth E., Elmhurst, Ill.
Wollaston, Eugene, Newark, Delaware
Woods, Ronald J., Midland, Mich.
Wright, Wesley, Jr., Richmond, Va.
Wuopio, Richard A., Sacramento, Calif.
Zelek, Raymond Donald, Ford City, Pa.
Zievers, James F., Evanston, Ill.
Zurkammer, Dean J., Lincoln, Ill.

Affiliate

Marples, David F., Charleston, W. Va.
Swalm, Dave C., Lake Jackson, Texas

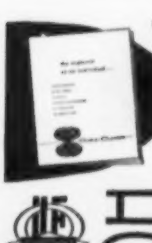


INTERESTED IN CREATIVE SALES ENGINEERING IN THE PROCESS FIELD?

If you're a sales-minded process engineer with or without experience . . . if you want to practice your profession as a creative individual . . . if challenge, variety and freedom of action appeal to you . . . you'll be interested in the opportunities for sales engineers in Dorr-Oliver.

Specifically, continued growth and expansion have created the need for engineers of varying levels of experience. Academically, a B.S. or M.S. in chemical, metallurgical, or mining engineering is preferred. Some experience in equipment sales or unit operations is ideal but not essential.

If this specification fits you . . . and most important, if you like the concept of the sales engineer as a creative individual, we would like to hear from you. A letter or resume to E. E. Johnson, our Director of Personnel at Stamford, Connecticut, is all that is needed. We'll do our best to arrange an interview at your convenience.



What do we mean by "creative" engineering? We'd like to send you a copy of "The Engineer as an Individual" . . . a new booklet which describes briefly our concept of the importance of the engineer to our worldwide operations

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CLASSIFIED SECTION

Address Replies to Box Number Care of CHEMICAL ENGINEERING PROGRESS

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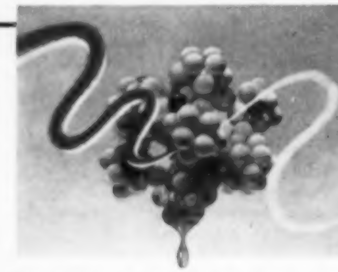
. . . about where you're going? We think we have a product with a big future, and now is a good time to get in on the ground floor. We need Chemists and Chemical Engineers to help us in our Molecular Sieve Development work.

If you are interested, write Mr. R. P. Kalle, Dept. **MS-7,** Linde Company, Division of Union Carbide Corporation, P. O. Box 44, Tonawanda, N. Y.



The Molecular Sieve Program covers

- Adsorption
- Separation of hydrocarbons
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- Process development
- Plant Design
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Opportunities in Chemical Process Operations

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Products are synthetic fibers, films, and plastics. Locations of our eight plants—Pennsylvania, West Virginia, and Virginia. Openings are technically challenging and offer good advancement opportunities. Applications are invited from B.S. and M.S. Chemical Engineers with 1-8 years of experience. Send resumes to:

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Recruitment Director
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Philadelphia 3, Pennsylvania

PROCESS DESIGN ENGINEERS

Chemical Engineers for applied chemical engineering unit operations in rapidly expanding Texas Division of Dow Chemical Company.

Duties involve translation of pilot plant processes to production scale plant, design calculations on distillation, heat transfer, mass transfer, fluid flow, and associated work. Processes are organic and inorganic.

Please send resumé to
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Technical Employment Department
THE DOW CHEMICAL COMPANY
Freeport, Texas

CONSTRUCTION MANAGER

Well established midwest engineering firm has responsible position available for manager of its construction activities. This is a high level management position, requiring capable individual with approximately 10 or more years' experience in the management and supervision of field construction of chemical or petroleum processing units. Salary commensurate with experience and proven ability. Replies will be treated in confidence. Box 2-8.

CHEMICAL AND MECHANICAL ENGINEERS
MATHEMATICIANS AND ENGINEERING ANALYSTS

ARE YOU CREATIVE? An idea man interested in bridging the gap between theory and practice?

Scientific Design—the world's leading independent engineering organization in the organic-petrochemicals field—is expanding its activities in Engineering Development. We are looking for a few additional outstanding engineering analysts to work on the frontiers of engineering science as applied to the design of chemical plants. The group has a magnetic drum digital computer available.

CAN YOU FILL ONE OF THESE CHALLENGING POSITIONS?

Theoretical Chemical Engineer: Capable of originating and solving complex problems in reactor design, heat transfer, mass transfer, distillation, absorption, etc., as well as the statistical design of experiments using advanced techniques.

Fundamental Mechanical Engineer: For the application of mathematics to the solution of advanced design problems in statics, dynamics, fluid mechanics, and joints as applied to chemical processing equipment and piping systems.

Process Control Analyst: The analysis of transient response of linear and non-linear chemical processing systems and the development of optimum control arrangements. Strong background in process control theory and servo-mechanisms.

Applied Mathematician: Experienced in numerical analysis, non-linear regression analysis, statistics, and the application of digital computers to the solution of **sophisticated** engineering problems. Will work closely with engineering analysts in translating physical problems into mathematical form susceptible to machine computation.

These job descriptions are intentionally incomplete. We are looking for individuals with the breadth and vision to originate their own programs. Applicants must have advanced degrees and at least two years' experience. Want to join this group? Reply in confidence to

Dr. Robert S. Davis
Director of Engineering Development
SCIENTIFIC DESIGN CO., INC.
2 Park Avenue, New York 16, N. Y.

SITUATIONS WANTED
A.I.Ch.E. Members

AVAILABLE

CHEMICAL ENGINEER

HIGHLY SKILLED

Interested in executive position with aggressive medium sized company. Prefer New York area. Currently earning $20,000'. Age under 40. Box 1-8.

CHEMICAL ENGINEER—Age 32, M.S.Ch.E. Nine years' experience with one employer in process development, process design, and manufacture of synthetic resins. Desire supervisory position with opportunity for advancement. Present salary approximately $10,000. Box 5-8.

CHEMICAL ENGINEER—High mechanical comprehension. Desire position in design, development or application of process equipment. Seven years atomic energy, synthetic polymers, miscellaneous chemicals. Desire opportunity to show how you can profit from this experience. Box 6-8.

ENGINEER-CHEMICAL ADMINISTRATIVE—B.Ch.E., '51, age 32. Six years' experience; product and process variable studies on military explosives and rocket propulsion units. Seeking technical management position—$9,000-$10,000 salary desired. Box 7-8.

(Continued on page 116)

PETROLEUM REFINERY CHEMICAL ENGINEERS

Positions involving technical service and consulting type work for petroleum refineries are available in Refinery Technology Division. Chemical engineers working in refinery process engineering or operation and economic analysis are well qualified for these positions. Positions offer a wide variety of work assignments in an expanding technical activity that works with sales, research, refinery, and company management problems. Positions also afford opportunities for industry-wide contacts with refining and process companies and for using initiative and individual expression to increase responsibility. Location in a Detroit suburb offers ideal professional environment with a choice of city or suburban living. For more particulars, send name and address to:

Personnel Manager,
ETHYL CORPORATION
1600 West 8 Mile Road
Ferndale 20, Michigan

MARKET RESEARCH ECONOMIC EVALUATION

Position open in expanding Marketing Group of Research and Commercial Development Laboratory.

Duties include preparation, evaluation, interpretation and presentation of business opportunities and product studies to Management for decisions and action. Some travel required. Headquarters—Charleston, West Virginia.

Training in chemistry, chemical engineering or marketing and some experience in the chemical industry required. Experience in market research, economic evaluation, technical service or sales desirable.

Contact Manager of Laboratory Services
Research and Development Laboratories
Westvaco Chlor-Alkali Division
Food Machinery and Chemical Corp.
South Charleston, West Virginia

WANTED

CHEMICAL ENGINEERS

One of the fastest-growing companies in the chemical industry, manufacturing heavy and fine chemicals, and plastics, requires engineers for process engineering. Work deals with process improvement, efficiency, quality, and equipment evaluation studies of existing plant processes. One to three years experience desirable but not necessary. Opportunity to obtain broad experience in technical problems of diversified chemical manufacture. Salary commensurate with experience.

Apply Industrial Relations Department,
HOOKER ELECTROCHEMICAL CO.,
NIAGARA FALLS, N. Y.

Sales Representative Wanted

MANUFACTURERS' SALES REPRESENTATIVES wanted by AAA-1 manufacturer of a new and proven wet scrubber-type dust collector line. Current representation of dry type collection equipment or experience in dust-fume collection required. Areas available—New England, Eastern Pennsylvania and Southeast. Box 3-8.

SITUATIONS WANTED

(*Continued from page* 114)

CONSULTING ENGINEER

Economic evaluations, planning, design for petroleum and petrochemicals industries. Highest qualifications. Box 18-8.

CHEMICAL ENGINEER—B.S.Ch.E., 1949. Varied experience in petroleum and appliance industries. Desire position in an activity where engineering background and experience can be used to advantage. Box 8-8.

TECHNICAL SERVICE ENGINEER—Age 35. Presently chief of section for research, development, and technical service for petroleum refining. Consider also chemical plant supervision or technical service. Rocky Mountain Area only. Box 9-8.

CHEMICAL ENGINEER—B.Ch.E. 1952, veteran. Three years' experience in process design, planning and economic evaluation in petroleum industry. Desire process engineering position with growth potential. Box 10-8.

PRODUCTION MANAGEMENT ENGINEERING—M.Ch.E. Fifteen years' experience in chemical food processing and aerosol packaging plants. Plant manager, process engineer, process evaluation and development, production supervision. Seeking responsible position in production management. Present salary $11,000. Box 11-8.

COST ENGINEER—Seek responsible post. Chemical engineering, estimating, cost control supervising background. Nineteen years' with major chemical company. Writing ability. B.M.E. degree. Box 12-8.

OVERSEAS POSITION wanted by chemical engineer speaking and writing fluent, French, some German, and Spanish. Six years' experience in heat transfer work, plant start-up and nuclear power plant design and economics. Box 13-8.

SENIOR PROJECT ENGINEER—B.S.Ch.E. 1947. Supervision of process development, plant design, and plant operation in A.E.C., chemical, metallurgical, and petroleum fields. Desire position in the research and development or engineering department of progressive concern. Box 14-8.

CHEMICAL ENGINEER—B.Ch.E., 1953, age 26, married, foreign born. Experienced in production, engineering, plant start-up, including supervision. Present salary $6,600. Will consider overseas assignment only. Box 15-8.

CHEMICAL ENGINEER—Age 30, family. Four years' plant engineering experience in heavy inorganic chemicals and two years' project engineering experience in latex and plastic coatings. Desire challenging and responsible position. N.E. portion of the U.S. Box 16-8.

CHEMICAL ENGINEER—B.Ch.E., P.E., 34. Seven years' experience production and process design in heavy chemicals and plastics. Desire challenging position in production or process design in Chicago area. Box 17-8.

CHEMICAL ENGINEER—B.S. 1950, M.S. 1954. Five years' experience in process engineering, process improvement and cost reduction. Some design experience. Desire challenging position with progressive company along same areas or economic evaluation. Fluent Spanish. Box 19-8.

people

Gov. Harriman of New York appoints **H. P. Munger,** chairman of Syracuse University's Chemical Engineering Department, as one of four new members of the State Air Pollution Board. Also appointed was **Jerome Wilkenfeld,** assistant technical superintendent, Hooker Electrochemical Co., Niagara Falls, N. Y.

Wilkenfeld

Burton H. Sanders resigns as process engineer with Thiokol Chemical Corp. to accept position as project manager with National Research Corp., Cambridge, Mass.

L. W. Moore, formerly executive vice-president of American Oil Co., has been chosen as the firm's new president.

New president of J. R. Minevitch and Associates, Boston, Mass., will be **George P. Lunt,** formerly an engineer and executive with E. B. Badger and Sons Co. Lunt succeeds Joseph R. Minevitch, recently deceased.

(*Continued on page* 118)

CHEMICAL ENGINEER—B.S.Ch.E., 1944. Age 34, family. Thirteen years' experience in nuclear plants. Want to develop operational limits, train operators, and start-up domestic or foreign commercial nuclear reactors. Box 20-8.

GENERAL MANAGER—SPECIALTY CHEMICALS business. Age 36. B.S.Ch.E. 1942. Fifteen years' experience includes sales, production, research and development, and general management functions. Qualified for and desire similar position, or sales development and/or staff position in larger company. Box 21-8.

EXPERIENCED CHEMICAL ENGINEER—Private laboratory facilities. Will accept investigational or analytical projects on a part-time or consulting basis. Detailed plots, calculations, and correlations of existing data made quickly and confidentially. Box 22-8.

CLASSIFIED SECTION RATES

Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

the chemical engineer in

MARKETING

Ray St. Onge named product manager of Process Instruments Division of Beckman Instruments, Inc. At the same time, **George A. Green** has been appointed Western district manager of the Process Instrument Division.

St. Onge

Beckman Instruments, Inc., names **Anthony M. Johnson** to post of product line sales manager, Systems Division. Johnson was formerly southeastern regional sales manager for Beckman's Scientific Instruments Division in Washington, D. C.

National Aniline Division, Allied Chemical & Dye, announces appointment of **Leslie C. Wizemann** as manager, detergent sales.

Douglas M. Considine joins Hughes Aircraft Co. as director of marketing for Hughes Products Group. Prior to his present association with Hughes, Considine operated his own marketing consultation firm in Indianapolis.

Catalin Corp. of America, Chemical Division, announces four new sales service appointments: **John Ziccarelli** to New York, **Herman Pickles, Jr.,** to Chicago, **E. B. Lee** to Houston, and **Glenn Nebel** to Los Angeles.

Jefferson Chemical Co. appoints **R. M. Roach** as New York district sales manager. Also, in Jefferson's Marketing Division, **R. J. Robinson** is being transferred from Cleveland to New York, and **J. M. Lugar** from Houston to Cleveland.

John W. Weaver, formerly assistant to the vice-president, assumes post of special representative of California Crude Sales Co., Perth Amboy, N. J.

Hooker Electrochemical Co. names **Thonet C. Dauphine** as manager of product development, plastics, in the Product Development Section of their Sales Department. Dauphine came to Hooker in 1951 from Oronite Chemical Co.

J. W. Hemphill, formerly associated with the Johns-Manville Corp., named sales manager for the Carthage Machine Co., Carthage, N. Y.

Necrology

Vasili I. Komarewsky, 62, professor of chemical engineering at Illinois Institute of Technology. Dr. Komarewsky pioneered in the development of synthetic fuels.

Carl Sundstrom, 79, formerly chemical engineer for Solvay Process Division, Allied Chemical & Dye Corp.

Joseph R. Minevitch, 65, president of J. R. Minevitch and Associates, Inc., Boston, Mass. Minevitch was a widely-recognized authority on industrial distillation practices.

50TH ANNIVERSARY PLANS PROGRESS

Chalfont

Carlson

McConomy

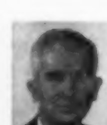
McCoy

Olsen

Grimble

Holik

Stark



Kinckiner

Here are the people who are devoting their time and efforts to making the 50th Anniversary Meeting of the A.I.Ch.E. an historical event. The week-long affair (Philadelphia, June 22-27, 1958), will be marked by an outstanding technical program and a wealth of entertainment opportunities. Highlights of the program will be announced in *CEP* as they are officially scheduled.

Members of the local arrangements committee for the 50th Anniversary Meeting of A.I.Ch.E. are:

W. E. Chalfont, General Chairman; W. E. Osborn, Secretary; W. M. Carlson, Treasurer and Chairman of Finance Committee; H. F. McConomy, Chairman, Hotels and Meeting Rooms; G. L. McCoy, Chairman, Registration; J. L. Olsen, Chairman, Entertainment; R. W. Grimble, Chairman, Printing; R. R. Holik, Chairman, Student Program; A. E. Humphrey, Chairman, Plant Trips; W. F. Stark, Chairman, Publicity; and Mrs. W. E. Chalfont, Chairman, Ladies Program.

INDEX OF ADVERTISERS

C.E.P. Advertising Offices

New York 36—Lansing T. Dupree, Adv. Mgr.; John M. Goede, Asst. Adv. Mgr.; Paul A. Jolcuvar, Dist. Mgr.; Donald J. Stroop, Dist. Mgr.; Hale H. Carey, Dist. Mgr.; 25 W. 45th St., Columbus 5-7330.

Chicago 11—Richard R. Quinn, Dist. Mgr., 612 North Michigan Ave., Room 507, Superior 7-0385.

Cleveland 15—Eugene B. Pritchard, Dist. Mgr., 1836 Euclid Ave., Superior 1-3315.

Pasadena 1, Calif.—Richard P. McKey, Dist. Mgr., 465 East Union St., Ryan 1-0685.

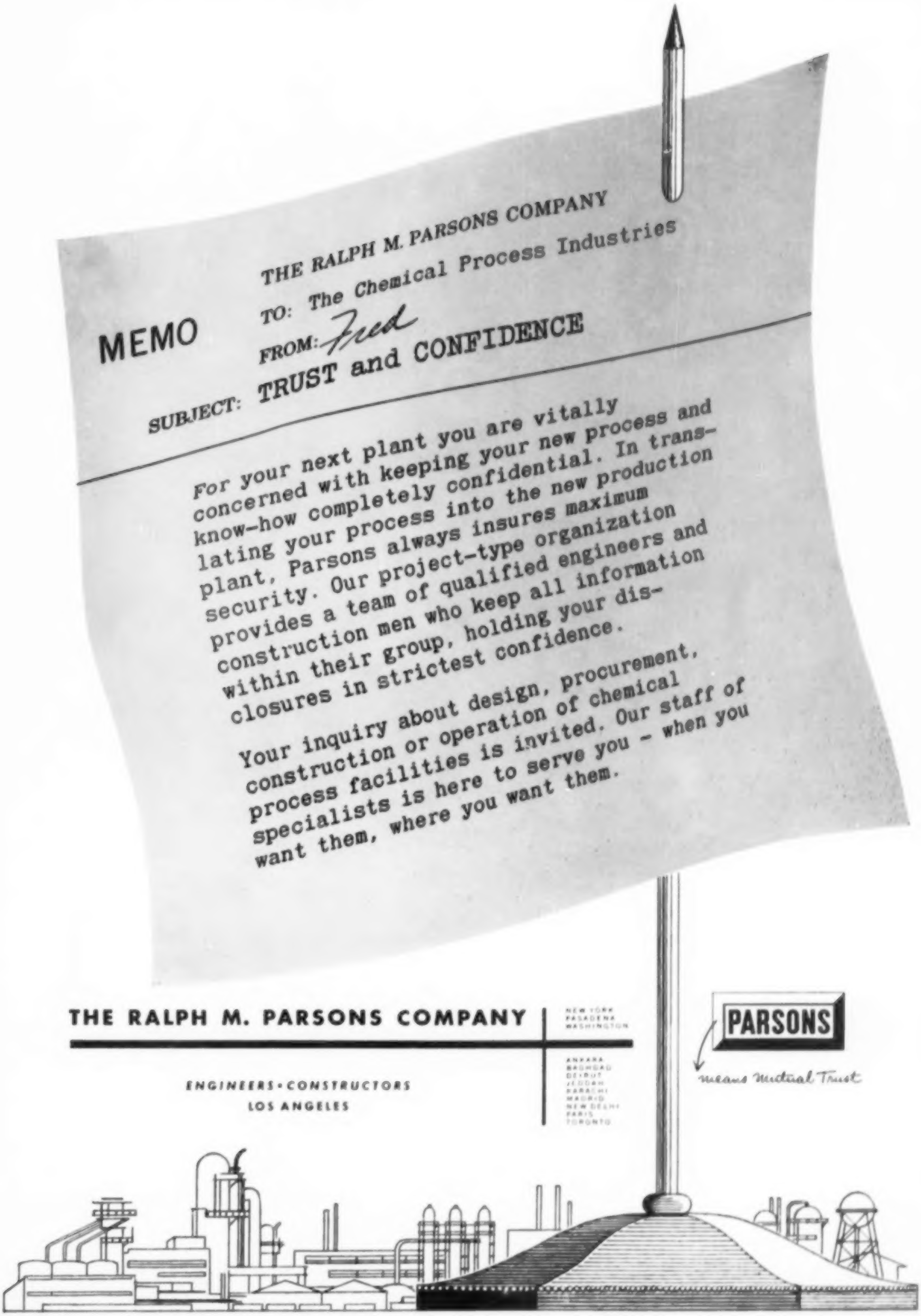
Dallas 28—Richard E. Hoierman, Dist. Mgr., 2831 El Capitan Drive, Davis 7-3630.

Birmingham 8, Ala.—Fred W. Smith, Dist. Mgr., 1201 Forest View Lane, Vesthaven, Birmingham 9, Ala., TRemont 1-5762.

news and notes of A.I.Ch.E.

Education and Accreditation Committee concluded an important piece of business at the Seattle meeting in formulating a definition of the first professional degree for accreditation . . . This is an excellent case in point of an A.I.Ch.E. committee's successfully resolving a problem that affects engineering in general . . . Recently a definition of the first professional degree became necessary to differentiate among graduate degrees & the committee recommended to Council, which accepted it, the following statement: "The American Institute of Chemical Engineers will consider for accreditation the curriculum of an institution which culminates in the first professional degree in an area of chemical engineering. In general, it shall be an engineering degree modified by an adjective (chemical, nuclear, process, petroleum refining) which indicates an area of interest to the Institute. The institution may award an earlier degree provided it is differentiated from the degrees for which accreditation is sought. It is immaterial whether the institution requests accreditation at the bachelor's or master's level. It is material that the curriculum & degree for which accreditation is sought be clearly specified." **Representing A.I.Ch.E.** on the American Standards Association Sectional Committee on Chemical Engineering for the Nuclear Field is W. W. Kraft of The Lummus Company, on the A.S.A. Special Standards Committee for Industrial Cooling Towers C. H. Gilmour of Carbide & Carbon Chemicals . . . G. G. Brown of the University of Michigan will represent us on Engineers' Council for Professional Development, Robert York of Cornell University on the Pump Standards Project sponsored by the Manufacturing Chemists' Association & the Hydraulic Institute & C. C. Furnas of the University of Buffalo on the National Committee of the World Power Conference. . . . **Site of New Engineering Building** has been determined by United Engineering Trustees . . . Some 37,500 sq.ft. of property in New York City located on the west side of First Avenue between 47 & 48 Streets has been purchased for about $2,700,000 . . . The site is directly opposite the United Nations Plaza . . . News story is carried in this issue. **Pump Manual:** A distinct advance for the A.I.Ch.E. Committee on Equipment Testing Procedures was reported by R. L. Jacks, Chairman of the Pump Subcommittee . . . A manual will be published sometime next year which will include not only a standard testing technique for centrifugal pumps, but also detailed information on specifications, ordering, pump parts, contracts, etc. . . . The work will be a major publication achievement & was so acclaimed by the members of Council at Seattle . . . Present plan is that this be published in loose-leaf form so that revisions and supplementary material may be easily added to it. **An ad hoc committee** was formed by Council to correlate a number of long-range problems that Council members have submitted for discussion . . . This is a continuing effort by Council to fashion a steady & intelligent growth pattern for chemical engineering. . . . **Other matters decided by Council:** Atlanta, Georgia, Meeting, February 21-24, 1960 . . . annual meeting at Houston, Texas, December, 1962 . . . co-sponsorship with A.S.M.E. for the Third U. S. National Congress of Applied Mechanics to be held at Brown University. . . . **Council also** reaffirmed its opinion that E.J.C. and E.C.P.D. should merge into one over-all united group . . . heard a report from J. J. McKetta, Chairman of the Membership Committee, which indicated that **A.I.Ch.E. was having one of its best years in the membership area yet** . . . Last year we had five members of the twenty-three–and–over club (members of the committee who had obtained twenty-three or more applications for membership) . . . This year we will go well beyond that . . . five sections have already received more than twenty-three applications & there are five more sections very close to that number. . . . Cotton Coulthurst also briefed Council on the semifinals of a complete reorganization of the Program Committee. **Annual report of the Rochester Section** was outstanding . . . Dick Boutros designed a snappy cover for it which shows Aristotle's postulate that all matter is made up of five elements & stemming from this the various stages of chemical knowledge to the present nuclear age . . . The report informs the Rochester Section members on all the activities of the section during the year plus the accomplishments of all of their local committees, retailed by the chairmen, & of the national committees on which they are represented. . . . **P. S. to Local Sections:** This issue shows the candidates selected by the Nominating Committee & those already nominated by petition . . . The last date for nomination by petition is October 7 . . . The election ballot will be mailed from this office on October 21 & will close on November 11.

F.J.V.A.


MEMO
THE RALPH M. PARSONS COMPANY
TO: The Chemical Process Industries
FROM: Fred
SUBJECT: TRUST and CONFIDENCE
For your next plant you are vitally concerned with keeping your new process and know-how completely confidential. In translating your process into the new production plant, Parsons always insures maximum security. Our project-type organization provides a team of qualified engineers and construction men who keep all information within their group, holding your disclosures in strictest confidence.
Your inquiry about design, procurement, construction or operation of chemical process facilities is invited. Our staff of specialists is here to serve you - when you want them, where you want them.
THE RALPH M. PARSONS COMPANY
NEW YORK
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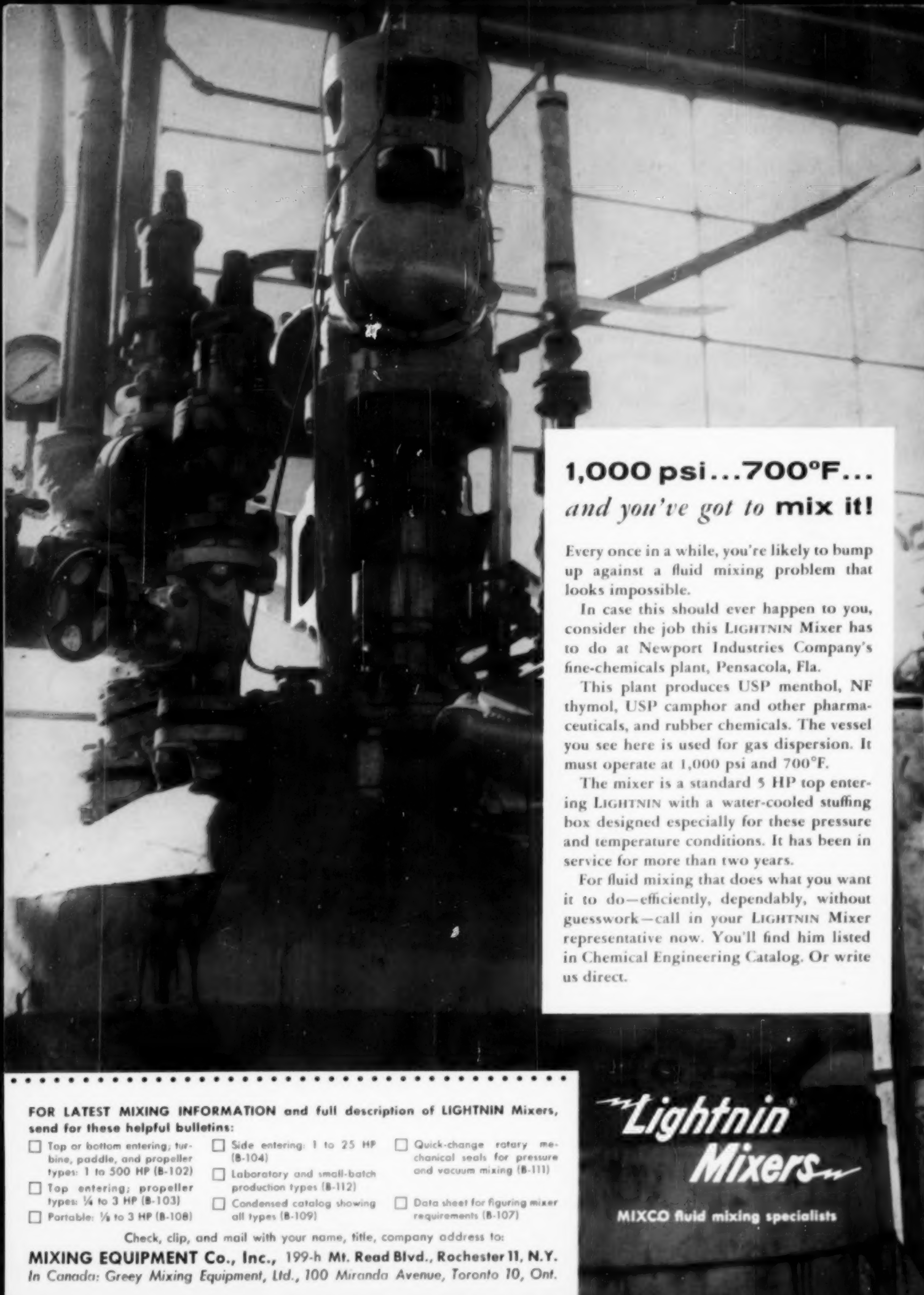
ENGINEERS • CONSTRUCTORS
LOS ANGELES
ANKARA
BAGHDAD
BEIRUT
JEDDAH
KARACHI
MADRID
NEW DELHI
PARIS
TORONTO
PARSONS
means mutual Trust



1,000 psi...700°F...
and you've got to mix it!
Every once in a while, you're likely to bump up against a fluid mixing problem that looks impossible.
In case this should ever happen to you, consider the job this LIGHTNIN Mixer has to do at Newport Industries Company's fine-chemicals plant, Pensacola, Fla.
This plant produces USP menthol, NF thymol, USP camphor and other pharmaceuticals, and rubber chemicals. The vessel you see here is used for gas dispersion. It must operate at 1,000 psi and 700°F.
The mixer is a standard 5 HP top entering LIGHTNIN with a water-cooled stuffing box designed especially for these pressure and temperature conditions. It has been in service for more than two years.
For fluid mixing that does what you want it to do—efficiently, dependably, without guesswork—call in your LIGHTNIN Mixer representative now. You'll find him listed in Chemical Engineering Catalog. Or write us direct.
FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:
☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
☐ Top entering; propeller types: ¼ to 3 HP (B-103)
☐ Portable: ⅛ to 3 HP (B-108)
☐ Side entering: 1 to 25 HP (B-104)
☐ Laboratory and small-batch production types (B-112)
☐ Condensed catalog showing all types (B-109)
☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
☐ Data sheet for figuring mixer requirements (B-107)
Check, clip, and mail with your name, title, company address to:
MIXING EQUIPMENT Co., Inc., 199-h Mt. Read Blvd., Rochester 11, N.Y.
In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.
Lightnin Mixers
MIXCO fluid mixing specialists